An innovation systems approach to sustainability transitions: Analysing socio-cognitive institutions in Austrian and South African cases

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Declaration

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Abstract

Choosing new socio-economic pathways for sustainable development requires one direction of economic development to be selected above another. This dissertation discovers which factors within innovation systems may lead to these trajectory changes. Little understanding exists of how socio-cognitive institutions (SCIs) within innovation systems (ISs) may enable or hamper this shift. The ability of nations and regions to direct socio-economic activity towards sustainability is an increasingly significant global challenge, with distinctive characteristics in different socio-spatial contexts. It is urgent that better comprehension of how transitions to sustainability can be induced within society is conveyed to those who need it. While the sustainability transitions (STs) literature confronts this problem, it neglects the finer intricacies of socio-economic influences of change, which may hamper or enable socio-technical transitions. In contrast, innovation systems, whether national, regional or local, do not confront the challenge of sustainability head-on, but arguably provide an excellent conceptual framework and policy tool for doing so. ISs also provide a strong theoretical framework for comprehension of these intricate mechanisms within national, regional and local economies, which may shift them to more sustainable trajectories.

This dissertation seeks to overcome this challenge. It will highlight the dearth of understanding of the configurations of a sustainability-oriented innovation system. It is assumed they are both social and institutional. This study aims to investigate the socio-cognitive institution, assumed to be crucial. From this a primary research question follows: How do SCIs within regional innovation systems (RISs) constrain or enable pathways to socio-economic development for sustainability, in turn affecting socio-technical transitions to sustainability at different structural and scale levels?

The primary research question is divided into three investigative themes and research sub-questions. This informs the analytical framework for a content analysis (CA) of the derived data stemming from the investigation of the case studies. What is investigated from an ethnographic and transdisciplinary research process is: *First*, how the strengths or weaknesses of ISs enable or constrain the ability of nations and regions to transform toward sustainability. *Second*, how sustainability-oriented SCIs may influence the direction of regional innovation systems (R)ISs, resulting in socio-economic pathways effecting STs.

Third, how SCIs form within ISs at macro, meso and micro socio-structural levels and national, regional and local geographic scales.

The derived data of the research in the form of interview texts are explored via a content analysis methodology. A rigid and deductive analysis framework is employed before an inductive approach is used to reflect on the extensive literature reviews of IS and ST theory. While the Austrian case represented an established sustainability-oriented RIS, the South African case 'Transforming Technopark' (TTP) in the context of the Western Cape Regional Innovation system was a contemporary and transdisciplinary case study. The transdisciplinary approach involved the researcher acting as a consultant, and co-developing a vision and strategy with various triple-helix stakeholders of the town of Stellenbosch. The study also extended to the regional level to gain perspective on the regional embeddedness of the case.

The findings of both cases strongly support the notion that SCIs are powerful enabling factors, within regional innovation systems. Their direction is strongly influenced by both internal and external factors in the RIS. SCI can exist as both informal and formal structures in society. Informal SCIs for sustainability may diffuse within the RIS to become formal SCIs. Knowledge generation for sustainability was recognized as the most important and powerful driver of both SCI change and the formation of sustainability-oriented innovation systems. The findings of the research, which are generalized to provide a theoretical background and model of sustainability-oriented innovation systems (SoIS), can be aimed at policy development for STs. The investigation was undertaken from a more macro-economic vantage point, of RIS. Recommendations are that more micro, business and organizational sets of perspectives of the influence of sustainability-oriented innovation systems on the functioning of the economy is now required. This would enhance the notional understanding of socio-economic transitions to sustainability considerably, and build upon what has been achieved in this study.

Opsomming

Sosio-ekonomiese weë moet verander om volhoubaarheid te bereik. Daar is min begrip vir hoe SCIs binne ISs hierdie verandering bevorder of terughou. Nasies en streke se vermoë om sosio-ekonomiese aktiwiteit na volhoubaarheid te stuur is 'n toenemende globale uitdaging, met kenmerkende eienskappe in verskillende sosio-ruimtelike kontekste. Terwyl die literatuur ten opsigte van volhoubaarheidsoorgange (STS) hierdie probleem aanspreek, word die verwikkeldheid van sosio-ekonomiese invloede op verandering van sosio-tegniese oorgange wat dit kan belemmer of bevorder, misgekyk. Andersyds konfronteer nasionale, streek- en 'plaaslike' vernuwingstelsels nie die uitdaging van volhoubaarheid regstreeks nie, maar voorsien 'n konseptuele raamwerk en beleid om dit te doen. ISs bied 'n teoretiese raamwerk om hierdie meganismes binne nasionale, streek- en plaaslike ekonomieë, wat dit kan neem na meer volhoubare trajekte, te verstaan.

Die tesis poog om hierdie uitdaging te oorkom en om die gebrek aan begrip vir die opsette van 'n volhoubaarheid-georiënteerde vernuwingstelsel te beklemtoon. Dit sluit beide sosiale en institusionele stelsels in. Die doelwit is om die krities-belangrike sosio-kognitiewe instelling te ondersoek. 'n Primêre navorsingsvraag is vervolgens: Hoe belemmer of bevorder SCIs binne RISs maniere tot sosio-ekonomiese ontwikkeling vir volhoubaarheid en, op sy beurt, hoe beïnvloed dit sosio-tegniese oorgange na volhoubaarheid op verskillende strukturele en skaalvlakke?

Die primêre navorsingsvraag onderlê die analitiese raamwerk vir 'n inhoud-analise (CA) van die afgeleide data wat spruit uit die gevallestudies. Wat ondersoek word vanuit 'n etnografiese en transdissiplinêre navorsingproses is as volg: Eerstens, hoe die sterk of swak hoedanighede van die ISS die vermoë van nasies en streke belemmer of bevorder na volhoubaarheid. Tweedens, hoe volhoubaarheid-georiënteerde SCIs die trajek van die plaaslike innovasie stelsels (R)ISS mag beïnvloed, wat lei tot sosio-ekonomiese weë wat STs bewerkstellig. Derdens, hoe SCIs binne ISs op makro-, meso- en mikro sosio-strukturele vlakke vorm, en nasionale, streek- en plaaslike geografiese skale.

Die afgeleide data in die vorm van onderhoudtekste word ondersoek deur middel van 'n inhoud-analise metode. ‘n Rigiede en deduktiewe analise-raamwerk word gebruik voordat 'n meer induktiewe benadering gebruik word om te besin oor die uitgebreide literatuurresensies van ISs en STS teorië. Terwyl die Oostenrykse geval 'n gevestigde volhoubaarheid-

georiënteerde RIS verteenwoordig, is die Suid-Afrikaanse geval van ‘Transformasie Technopark’ (TTP) in die konteks van die Wes-Kaapse Streeksvernuwingstelsel, 'n kontemporêre en transdissiplinêre gevallestudie. Tydens die transdissiplinêre benadering het die navorser as konsultant opgetree, en was mede-ontwikkelaar met verskeie trippel-heliks belanghebbendes van Stellenbosch. Die studie het ook uitgebrei na plaaslike vlak om perspektief te kry op die plaaslike verankering van die saak.

Die bevindings van beide gevalle ondersteun die gedagte dat SCIs belangrike bemagtigingsfaktore binne plaaslike vernuwingstelsels is. Hierdie neiging word beïnvloed deur beide interne en eksterne faktore in die RIS. SCI mag bestaan as informele en formele strukture in die samelewing. Informele SCIs tot volhoubaarheid mag binne die RIS ontplooi en dus formele SCIs word. Kennisuitbreiding van volhoubaarheid word erken as die belangrikste en mees invloedryke faktor van SCI verandering, en die vorming van volhoubaarheid-georiënteerde innovasiestelsels. Die bevindinge van die navorsing wat veralgemeen word na 'n teoretiese agtergrond en model van SoIS lewer, kan gerig word op die ontwikkeling van beleid vir STs. Die ondersoek poog om 'n groter makro-ekonomiese oogpunt van RIS te bewerkstellig. Aanbevelings is dat 'n groter mikro-, of sake-perspektief van die invloed van volhoubaarheid-georiënteerde vernuwingstelsels op hul sakemodelle vrugbare toekomstige navorsingsrigtings mag bied.

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List of acronyms and abbreviations

ANT	Actor network theory
CA	Content analysis
CNM	Conceptual Niche Management
COFISA	Cooperation Framework on Innovation Systems between Finland and South Africa
DEDAT	Department of Economic Development and Tourism (Western Cape)
DST	Department of Science and Technology (South African)
EE	Evolutionary economics
EM	Ecological modernisation
EU	European Union
GVC	Global value chain
IS	Innovation system
ISDRS	International Sustainable Development Research Society
GOST	Geography of sustainable transitions
ICT	Information and communication technology
KITI	Knowledge, innovation and technology infrastructure
LDC	Developing or less developed country
LIS	Local innovation system
MDG	Millennium Development Goal
MLP	Multi-level perspective
MNC	Multi-national company
NIS	National innovation system

OECD	Organisation for Economic Co-operation and Development
PD	Positive deviance
RIS	Regional innovation system
RQ	Research question
SCI	Socio-cognitive institution
SCOT	Social construction of technology
SD	Sustainable development
SID	Stellenbosch Innovation District
SIS	Sectoral innovation system
SNM	Strategic niche management
SOE	State owned enterprise
SoIS	Sustainability-Oriented Innovation System
SPIS	Science Policy and Innovation Studies
SPRU	Science Policy and Research Unit
SRA	Special Ratings Area
ST	Sustainability transition
STS	Science and Technology Studies
TD	Trans-disciplinary
TIA	Technology Innovation Agency
TIS	Technological Innovation System
TM	Transitions management
TTP	Transforming Technopark

1 CHAPTER 1 - Introduction

'If we don't change our direction, we are likely to end up where we are headed.' (Ancient Chinese Proverb).

'The direction of the mind is more important than its progress.' Joseph Joubert, French Moralist (1754 - 1824).

1.1 The research problem, arguments and aims of this dissertation

There are three main themes of investigation or arguments in this dissertation. *First*, the dissertation provides a better understanding of how innovation systems (ISs) provide capacity for sustainability transitions (STs). Bearing in mind that the strength of ISs varies greatly between regions, it is argued that regions with stronger, higher quality, well-functioning ISs have better capacities and opportunities for STs. Conversely, regions with weaker ISs may find it difficult to steer their economies and infrastructures in more sustainable directions. However, strong ISs do not necessarily have the direction or quality we are concerned with. The *second* point of investigation and argument is based on the premise that the socio-cognitive frameworks of actors forming special institutions in ISs determine this quality leading to socio-economic pathways for ST. Socio-economic pathways, like socio-technical pathways are specific trajectories of development with inertia. This means they are rigid to change, but they can be shifted through innovation – both social and technical innovation. The *third* theme focuses on the notion that socio-cognitive institutions (SCIs) exist, are influenced and differ at various structural and scale levels. The socio-spatial dynamic is a complex one, in terms of influence of SCI structures and *vice versa*. The proximities literature provides a useful theoretical foundation to unpack this dynamic. These themes provide significant insights into the governance of STs from an IS perspective. Specifically they address the potential naivety of a universal approach to STs by emphasizing the subtle differences between socio-economic and institutional contexts in specific socio-spatial regions.

1.2 Premise

Unsustainable human activities on this planet have placed excessive pressure on global ecological systems. Social injustices, inequality and poverty abound, and many of the millennium development goals (MDGs) have not been reached. In 2015 the sustainable

development goals (SDGs)[1], take over with an additional emphasis on shifts towards more equitable, inclusive and environmentally conscious socio-economic growth paths. Economic systems of the world are failing the poor, and more recently the rich as well with the collapse of financial markets and their assets. This collapse has perceivably put global growth trajectories back by decades, which may be a 'saving grace' for environmentalists. However, at the same time it may restrict wealth creation in developing countries, and for the masses of excluded societies whom have yet to benefit from economic growth. Perhaps it is not the change in the rate of growth, but the direction and quality of growth that will make the difference in socio-economic pathways that are more included, and environmentally conscious. This is possibly what the moving target of sustainable development (SD) requires globally and locally. The theory of STs is a promising new research avenue that tackles this question directly from a 'socio-technical' approach, and could be strengthened by a deeper innovation systems approach but also a wider socio-economic perspective. There is scope for strengthening and expanding it, especially as IS theory may yet provide the best analytical tool and suggest the best capacity-building approach for STs.

Depending on one's perspective, crises of various kinds may provide windows of opportunity for change and transitions to a new era of inclusive sustainable development. Crises in any individual area take place intermittently, but across the fields of society, the economy and ecology they occur all the time. They provide fuel for change when governments and individual leaders recognize the need to shift mind-sets and SCIs towards a new paradigm of SD. Crises create opportunities to effect necessary change. However, while change may begin with the mind-sets of individuals, groups and communities on the ground, they are often hampered from bringing about such change by dominant economic and political forces. These forces are often inscribed in the 'mainstream ideals' and worldviews of the powerful elite minority, and embedded in institutions of culture, political systems, innovation systems, education systems and economic systems. These power structures or incumbent regimes do not exist universally in the same form, but rather play out in actual regions, spaces and places. At the same time local spaces and institutions, through alternative thinking and practices, can counter mainstream or global socio-economic structures as both spatial and conceptual niches. Regions, cities and districts in fact often lead change for sustainability and inclusive development, moving against the global, mainstream currents. When this happens,

[1] www.unep.org

the regions usually have strong capacities and resources to enable these changes, backed by leadership that encourages innovative thinking.

The opposite kind of leadership can be marked by socio-cognitive and institutional, inertia. The power of this inertia is intangible, but is patent everywhere – in communities, in villages, in economic zones, in science and technology parks in cities and regions. In the knowledge economy, these places thrive or decline through the quality of decision-making in spending, determining directions of search, research and development, and governance. They represent regional and 'localized' systems of innovation that eventually determine and steer the rate, quality and direction of development. In these RISs socio-cognitive institutions in the form of attitudes, values, mind-sets and forms of knowledge, continuously compete, playing a fundamental role in shaping the current and future trajectories of social and technological development. This dissertation pursues the notion that the role, quality and direction of innovation systems are determined by competing socio-cognitive institutions at different structural and scale levels, and that SCIs thereby determine transitions to sustainability through ISs.

Past thinking and knowledge has shaped the world we live in today. It integrates social and technological infrastructures in urban regions, cities, towns and districts. The shapes and designs of these social and technological infrastructures in turn shape us, potentially leading to a position of socio-technical lock-in to inappropriate development paths. Breaking away from these paths of unsustainability, will require not only the re-imagination of urban life through new thinking, innovation and visions for sustainability but also ways of putting the new vision into practice, through managing transitions. Changing mind-sets and supporting socio-cognitive institutions for sustainability and inclusiveness need to go hand-in-hand with implementation of new designs, of sustainable technologies and infrastructures.

Implementing innovative and inclusive alternatives in place of unsustainable socio-technical systems creates tangible change for sustainability in our societies. Pilot projects, new experiments and new spatial nodes of development for sustainability may have far greater impact than expected because of their 'knock-on' and learning effect in a region and more widely. The physical embeddedness of social and technical change for sustainability is a requirement for promoting alternatives to mainstream dominant unsustainable regimes. In other words, seeing is believing. But at the same time, there are limitations. Isolated islands of change are unlikely to bring about wider change across regions or geographies, because

the contexts and conditions of scalability and institutional governance vary considerably at different scale levels. These 'experiments for change' need to happen, but not in isolation. They need to become places of learning, as 'hopeful monstrosities' to challenge and replace incumbent unsustainable regimes (Mokyr 1990). Without bottom-up experimentation, the tyranny of imposed top-down conventional approaches to development will stifle the innovation and entrepreneurship which is most needed to find solutions to local problems.

In the global transition to sustainability, change cannot possibly take place uniformly across geographies. It will take place, and is taking place, in regions of the world that have adequate capacity. This is good, because there needs to be leadership by those economically active places that have the ability to start transitioning right away. Knowing or assessing if a region has the ability or capacity to enable such change is useful and it is possible to do this through investigation of its regional and national innovation system strengths and qualities. Regions with weak ISs may struggle to implement change at the same rate and to the same lasting effect as strong innovation regions. In this dissertation, transitions to sustainability are assumed to be dependent on two factors: the level of functionality of the innovation system, and, more critically, the socio-cognitive mind-sets of actors and institutions in and supporting the system. However, these dynamics are different, and vary between, and within, scale and social structures.

'Pockets of change' of the kind we have described do not guarantee change on wider levels or geographic scales. But, they may signal that a region has the capability to transition to sustainability. Accordingly, model districts, towns and regions for sustainability should not be promoted as the product of new policies only; they should be seen as opportunities for stimulating and strengthening partnerships, for building the regional innovation system's capacity to support new ideas and innovative business committed to inclusive sustainable development. Guiding visions are important for sustainable districts, urban or rural spaces. But they need to be backed by the political will, community buy in and above all resources, to provide genuine incentives for promoting alternatives. Such a process is iterative, since ISs provide the capacity and the vision of the spatial region or project and provides the rationale for investments. Visions for sustainability also create the possibility of learning and changing mind-sets through expanding socio-cognitive institutions in innovation systems. Some failures in this approach are inevitable, and specific ST goals may not be achieved. However, failure should be seen as part of the transition learning process.

Stimulating ISs through regional, spatial visions for sustainability in the less-developed regions of the world has great potential to become a strategy and policy directive for inclusive sustainable development. Leapfrogging old mind-sets, creating new socio-cognitive institutions to support RISs goes hand in hand with accepting new methods, technologies and approaches to development. This is achievable.

1.3 Introducing key theories and concepts

Innovation systems (IS), and more specifically regional innovation systems (RIS) literature will form the primary theoretical lens in this dissertation, whereas sustainability transitions (ST) will form the second most relevant body of literature. These literatures do not represent uniform theories, but rather stem from an array of different academic disciplines and research fields ranging from neo-classical economics to evolutionary, institutional and ecological economics; from sociology to psychology and behavioural studies; from political science to management and organizational studies.

The literature on ISs and STs offers multi- and inter-disciplinary theories, making possible a rich and complex combination of insights and ontological approaches in relation to sustainable development (SD). The concept of SD has developed over the years to cover considerably diverse research fields, theoretical and practical approaches. Because of its heterogeneity, SD serves as an overarching concept and framework in which theoretical considerations can be explored. ST theory can be viewed as a valid approach to SD.

One difference between ST and IS theories is that the former is explicit from the outset in informing and contributing to the debate and informing policy for SD. In pursuing its main theme, this dissertation aims to explore aspects of the importance of ISs for STs. It is a large field, so boundaries and focus are required. Hence the RIS perspective, one component of the IS and ST literature, is the main focus of the dissertation. The case study analysis framework that is derived from the literature explicitly excludes the literature on STs. The aim is to contrast ISs approaches to STs with the theoretical background of ST theory in mind, drawing on aspects of the Multi-level Perspective (MLP) and Geography of Sustainable Transitions (GOST), literature for example. The insights and findings derived from using only the ISs as a lens for the investigation of socio-economic change provides new insights into STs. These are discussed in the final section of the dissertation in the reflection on the literature on STs. The aim of this is to gain new perspectives and theoretical generalizations from ISs for STs. In the opinion of the researcher, ISs in theory and practice have

considerable potential for expanding the debate, practical approach, and policy directives for STs.

1.3.1 Innovation systems

Although IS theory is young, there are already many divergent approaches to and understandings of the concept. A brief explanation of how the term is used in this dissertation is given below. There is a more formal account and review of the literature in Part I.

Innovation systems theory refers to an analytical tool to assess the interaction (both quality and quantity) between elements and mechanisms that make up innovation processes, their outputs as innovations, and their subsequent diffusion.

Elements refers to actors (individuals, organizations and firms), institutions, knowledge and innovation infrastructure (e.g. universities, research and development {R&D} labs) and policy.

Internal mechanisms refers to interactive learning (between the elements), proximities (e.g. geographical or social), embeddedness (i.e. of knowledge, institutions, infrastructure etc.), knowledge production (e.g. exploration in a university, and search in firms) and financing. These aspects function collectively as a system to produce innovation and diffuse it in society. Thus the object of study refers not only to the components of the system, but to the quality and quantity of ties between the components as weak, strong or functional innovation systems. ISs are generally spatially embedded in economic regions or geographies, but can also span across geographies through extended social and organizational networks, usually focusing on specific technology platforms and sectors.

The primary theoretical lens for this dissertation is RIS theory. It is part of general IS theory, which is largely based on the idea of a national innovation system (NIS). The distinction between RIS and NIS is the geographic region as opposed to the nation as a unit of analysis. RIS theory understandably places a greater emphasis on geographical space and social proximities and their relation to innovation processes. This emphasis is germane to the dissertation. However, although RIS is the primary theoretical lens, reference will be made to insights into national, sectoral and technological innovation systems in the literature review.

1.3.2 Sustainability transitions

Sustainability transitions theory treats the phenomenal world as a socio-technical reality in understanding how to effect change for sustainability. The role of the 'technological' cannot be understood apart from the adoption of technology by society to establish new ways of living and doing. Hence the combined terms of social and technical become the construct 'socio-technical'.

Transitions theory has developed by analysing the dynamics of transition processes in cases where particular socio-technical systems have transitioned, over time and in relation to other incumbent socio-technical systems, to new socio-technical systems in a process known as system innovation. In some cases this happened rapidly and in other cases it was slower, so time is an important factor in the theory. Understanding transitions through time has opened the door for the development of several sub-theories, such as the multi-level perspective (MLP), strategic niche management and transitions management (Grin, Rotmans & Schot 2010). The multi-level perspective or MLP has gained significant traction as a middle-ground theory, and has been useful in guiding the debate about transitions to sustainability. Understanding why and how transitions take place was studied from a historical perspective to derive clues on to how to manage contemporary transitions.

In this dissertation, the literature on STs provides a theoretical framework in which wider socio-economic transitions are analysed and discussed. The notion of socio-economic transitions leading to socio-technical change is emphasized through the use of RIS as a lens of investigation. The question of how ISs may enable strategic 'spatial' niches or regional scales, and enable transitions on a wider scale is of particular interest. This investigation is in line with the recent assertion that transitions take place in specific geographies and places, recognizing the importance of scales (Raven *et al.* 2012; Coenen 2010). The geography of sustainability transitions is thus a leading-edge school of thought relevant to the case studies in this dissertation.

Another core concept which cuts across both sets of literature as a more phenomenological concern is socio-cognitive institutions (SCIs). This concept is mentioned in both sets of literature, but is not comprehensively dealt with in either. This may have diluted its significance. In the next paragraph and then throughout the dissertation an effort is made to both define socio-cognitive institutions and highlight their relevance to the transitions to sustainability debate.

1.3.3 Defining socio-cognitive institutions

In order to develop a working definition of 'socio-cognitive institutions' in the context of ISs and STs for this dissertation, a brief literature review is appropriate at this point. This is necessary because there is no universally accepted, formal definition of socio-cognitive institutions, and the term has been used in different contexts with varied meanings[2]. The aim of this sub-section is to clarify those meanings and propose a single one, relevant to ISs and STs.

Akkerman *et al.* (2007) provide a review of the concept of socio-cognitive and 'group' cognition from the educational and psychological sciences. The insights gained from this review, are also relevant to the wider 'institutional' view. They point out that the concept of cognition should be understood in the context of two varied socio-genetic approaches. Traditionally, cognition is seen as a singular and isolated phenomenon of the individual. However, more recently, cognition is recognized as always taking place in the context of society and learning. At the one extreme there is a separation between individual cognition and society in the sense that the individual and society are separate units, but also related to each other; and at the other they are inseparable. As described in summary the first view is that:

> Underlying cognitive perspectives, the individual is seen as an autonomous agent, an active person who constructs personal understanding of the world surrounding him or her. This understanding is reflected in a mental network of internal constructs of meaning stored in memory. The social world surrounding the individual is seen as a set of social contexts in which the person acts.

And the other that:

> Underlying the socio-cultural perspectives, the individual is seen as a participant in social practices, in which he/she is interacting with others and with material and representational systems. Participating in social and cultural practices contributes to the construction of the participants' dispositions to agree with certain propositions or routine practices, and as such to his or her identity. The socio-cultural perspectives do not deny the existence of an individuals' mind, nor its agency, but they understand this mind as situated in the participation processes in systems of socially organized activity that are themselves evolving.
>
> (Akkerman *et al.* 2007:42,43)

[2] For example as contrasted in business and organizational studies which are more focused on individual decision-making at the firm level. Here there is a need to understand SCIs also on a wider socio-economic level within ISs, in other words not only within organizations, but between them as institutions. The thesis intends developing such a view of SCIs and has purposefully not limited SCI to the more micro, organizational literatures. See for example (Akgün et al. 2003) for an overview the management and organizational approach to SCI.

The institutional view of the socio-cognitive places the emphasis on the institution as opposed to the individual. In other words, above, the individual perspective on cognition is prominent, albeit in context of society; in the institutional view, the opposite is true in the sense that socio-cognitive refers to the wider unified group perspective and not to a collection of individual thoughts, which may vary. The group's view becomes an accepted norm or institution. The socio-cognitive perspective is taken to be 'true': it becomes a rule for operating by, and a means of identification. It becomes the generally accepted awareness or consciousness of social groups and of wider society.

Reviewing the work of several authors who focus on socio-cognitive and institutional theory (Akkerman *et al.* 2007; Dillon 2000; Garud & Ahlstrom 1997; Garud & Rappa 1994; Howells 1995; Menary 2013), two themes arise for innovation theory.

First, the term 'cognitive' implies a knowledge component, which can be based on past learnt experiences and learning as interaction with new knowledge or experiences. Most of these authors talk about this knowledge and experience as the cognitive framework of an individual, or as 'socio' cognitive in the case of the shared frameworks of groups in society (Klimoski & Mohammed 1994; Raven & Geels 2010). For SCI, shared cognitive frameworks have been referred to variously as common ground, team mental models, shared understanding, distributed cognition and collective mind. These terms, '*all refer to structures of collective meaning that emerge in and coordinate the activities of a group'* (Akkerman *et al.* 2007:40).

The purpose of group coordination activities is associated with creating meaning in groups, also known as sense-making. This highlights the *second* general feature of SCI: the way in which cognitive institutions are formed for the purpose of sense-making. When this happens – when values, norms, perceptions and beliefs of groups in society or between groups in society become shared – an institution is formed. Sense-making is thus about creating institutions or shared rules of understanding: what have been called 'cause maps' in groups and in society. Cause maps are described as

> particular sets of attributed causal relationships between remembered events which may make sense of enacted events. Those which aid the effort of making sense of enacted events will tend to be selected, while those which do not will tend to be ignored.
>
> (Howells 1995:887)

This understanding of cause maps as socio-cognitive institutions is important because it explains how choices are made as collectively defined selection processes. This eventually leads to the associated notion of path-dependency or technological trajectories of development. Eventually these may lead to specific socio-economic pathways or trajectories. Cause maps as or in socio-cognitive institutions eventually determine the technology choices and innovative direction of groups in society. Against that background, we can attempt a definition:

Socio-cognitive institutions – are the collective bodies of knowledge cultures, as established patterns of information flow and thinking, and the attitudes, norms and values inherent in society.

A *formal* socio-cognitive institution is the body of knowledge, approaches to knowledge generation and cognitive learning ability of society as an institution. However, an important detail is that deep cultural traits and 'ontologies' are also included as formal SCIs. This is because knowledge that is derived from being 'taught' for example at a University should not be distinguished from knowledge that is derived through learning in society. For example, traditional knowledge, and cultural practices are often not taught, yet constitute deeply engrained socio-cognitive institutions. Formal SCIs are usually shaped over longer time periods, and are difficult to change. They are deeply institutionalised.

Informal socio-cognitive institutions may relate to more short-term attitudes, perspectives, norms and cultures of information gathering and learning in society. They are malleable and quite easily changed, and represent fads, or trends in society. Eventually, through their expansion or deepening through accumulation of a body of knowledge that is held in society, they become formalized (over time). For example, informal SCIs may become formalized SCIs through absorption in ISs. Research programmes may deepen cognitive frameworks of actors in ISs, further institutionalizing and spreading the SCI. Formal and informal SCIs may thus vary considerably between different structural levels and in different geographic contexts.

For an overview of important concepts and definitions of key terms used in this dissertation, please refer to Appendix A1.

1.4 The global sustainability challenge

The fate of many humans on the planet will be decided in the next few decades. Achieving SD and harmony in this short period seems unlikely. Current mind-sets and the ideals of those in power often seem to be hardening to self-serving ends. Global leaders, through alliances, treaties, trade agreements, as well as through the guise of development aid, often further their own interests at the expense of the weaker nations. However, there have also been significant gains in human development. In many parts of the world the millennium development goals (MDGs) have ushered in significant progress towards development. Advances in healthcare, education, transport, trade, social benefits and achieving peace and stability should not go unrecognized (UNDP 2014; United Nations 2015). Many initiatives, from a global to a local scale have done well to advance and promote human development and ecological goals whilst growing their economies. Unfortunately however, these initiatives have still not been able to curb the negative trajectories of unsustainable development, recognized in the pledge of the next sustainable development goals (SDGs) from 2015 to 2030 (United Nations 2015). It has been suggested that development trajectories require not only urgent change, but radical change through complete socio-technical and socio-economic regime shifts to SD through innovation of entire socio-economic systems. Geels (2011) suggests this requires a factor-10 shift in ecological effectiveness from current trajectories. For this to happen, system innovation of socio-technical incumbents is an imperative.

SD is defined as 'meeting the needs of current generations without compromising the ability of future generations to meet those same needs'. A commitment made by nations of the world through the Brundtland commission some fifty years ago is quite literally failing (Gillespie 2001; Brown 2011). The first global summit on SD was in Rio de Janeiro in 1992, which spelt out global targets for emissions reductions and SD. Some twenty years later, the follow up meeting of Rio+20 has come and gone, and the global discourse about SD continues whilst the unsustainability of modern societies is more firmly established than ever. The mainstream economic development model, emphasizing growth and individual consumption, remains unchanged. The hopes that the Brundtland report for improvement of technology and social organization would lead to an era of sustainable economic growth have not yet been realised. Targets are also moving. There are now 1.5 billion more people on the planet than twenty years ago and trajectories are showing continuing and rapid ecological degradation. It is now well understood that the dominant systemic features of the current global economic system are unsustainable (Söderbaum 2000; Swilling 2010). Numerous indicators show

economic activity to be a direct cause of global environmental instabilities and social inequalities including climate change, resource depletion, eco-system and habitat destruction as well as an increasing gap between rich and poor (UNEP 2011a; SoTW 2010).

The increasing need for economic system transitions toward more sustainable trajectories is evident and a pressing concern for policy makers worldwide (Elzen *et al.* 2004). Innovation for sustainability is considered key to achieving a more sustainable world (UNEP 2011b). This indicates an urgent need to reform or replace mainstream understandings, ontologies and conceptualizations regarding development, human progress and our relation to nature (van Heyningen 2009). Furthermore, while there is a need to recognize the fundamental inadequacies of the ecological modernization (EM) project (Hajer 1995), it remains the dominant paradigm adopted by national governments to achieve SD. While technology and market mechanisms are important, and trusted as key dimensions in the solution framework of EM, they are likely to remain key parts of the problem. In the transition management literature 'persistent problems' arise due to market inefficiencies (Rotmans & Loorbach 2010). To enable rapid transitions to sustainability, there is also a need to emphasize new dimensions of innovation. Innovation can be seen as a vital function of progress, but remains deeply rooted in mainstream conceptions of economic progress alone. The need to re-conceptualize and understand what progress means in the context of the human survival project is clear. An emphasis on socio-technical transitions to SD through sustainability-oriented innovation systems is likely to be a key factor in achieving sustainability for a global society.

1.5 Introducing the research problem

The research problem is first explained from a broad perspective, and then narrowed down into three integrated or nested research problems. These become the three investigative themes of the case studies, and inform the research questions. From a broad perspective, the 'problem of (un)sustainability' can be generalized as a 'structural' issue in societies and economies. Generally, 'structures' here refer to integration of social systems and economic systems. Social systems include: institutions, cultures, politics, religions, world-views or ontologies, ethics, moral standards, norms and values. They importantly retain, but also act upon their available sets of knowledge and information. These institutional phenomena are not only intertwined with technological systems (as socio-technical), but also economic systems (as socio-economic). Each system is inseparable, and collectively and iteratively

shape and steer one another. The key issue that is raised here is that there is little knowledge by policy makers, governments nor academics on how to steer these socio-economic systems towards a sustainability direction. Innovation systems (ISs), however, conventionally used as a tool to guide economic growth have considerable potential to be used as a tool to enable socio-economic transitions to sustainability. This is yet to be investigated from a SCI perspective.

The approach to the problem of unsustainability within the economy in this dissertation uses a distinctly social and institutional lens in viewing socio-cognitive institutions. It is assumed that features of the economy including infrastructures are socially constructed and are designed within the contexts of prevailing and competing SCIs[3] within the economy, and ISs. The economy is essentially a social and institutional phenomenon, and can be adapted and steered according to various internal and external societal pressures. These may be influenced by external shocks like environmental disasters, or altered trends in science, new knowledge and information, but ultimately it is socio-cognitive institutions (SCIs) that steer the direction of ISs, which in turn steer economies.

Adding to the 'environmental sustainability' dimension of the general problem, unlike socio-economic systems, natural and ecological systems are not dependent on society for their functioning. Yet, ultimately there is a disjunction between the SCIs of society and their known dependency on natural systems. There is a clear need to recalibrate the SCIs of societies to take into consideration ecological systems in relation to socio-economic systems. Transitions of socio-economic systems, through sustainability-oriented ISs are assumed to enable and affect socio-technical system transitions as well. Without such a shift in the mind-sets and SCI of actors within ISs, socio-economic systems will be undermined by their destruction of ecological systems. This balance must be restored and this shift begins within the SCIs of societies to willingly and knowingly affect such a shift. This is the broad issue and challenge that humanity faces. There is some, but little understanding of how this can be achieved rapidly enough to avoid collapse of our social and economic systems. Another issue, is that SCIs, also need to shift to become more socially inclusive. The global and national economies are now at their peak of income inequality.[4]

[3] See the social construction of technology (SCOT) (Bijker et al. 1987) and Actor Network Theory perspectives which share a similar view (Callon 1986).
[4] www.oxfam.org

Technological systems form an intractable part of socio-economic structures, and they too cannot be separated from social systems. Yet societies design, innovate, implement, construct and use technologies on a daily basis that are unsustainable. They contribute, knowingly and unknowingly to the perpetuation of socio-economic and socio-technical systems further entrenching unsustainable practices. The problem is not only about societal awareness, and a consciousness that that socio-economic systems are unsustainable – but rather why this is so and why does it perpetuate – even when it is known that the continued trajectories of socio-economic impacts are unsustainable.

The problem on a broad level can thus be seen as an issue of the need for systemic change, and how can one possibly bring this about. Whereas ST literature focuses on the problems of lock-in of socio-technical systems, and how to change this, this dissertation includes in the problem framing the need to shift unsustainable economic trajectories to more sustainable ones.

The qualities of SCIs in general, and for sustainability are assumed to be heavily dependent on the availability of knowledge and information. ISs and their functioning are a good lens with which to view the issue of qualities of SCIs. This includes the elements within ISs that create and are shaped by SCIs, and the various institutional channels that ensure their diffusion in society. The economy functions because of society, but also for society – and ultimately the control of the direction of the economy lies within the collective minds of societal actors as SCIs. ISs provide a good framework to focus the broad and generalized research problem stated as:

Socio-economic pathways need to shift course, and there is little understanding of how SCIs within ISs may enable or hamper a shift towards a more sustainable direction.

However, this problem is too broad for a PhD research study, and can be narrowed to a set of research problems. This is dealt with from the specific theoretical lens of regional innovation systems (RIS). RISs theory, as explained above, provides a narrower problem framing, and is known to steer economies. Gaining a better understanding of ISs, and more specifically RISs becomes a more suitable theoretical lens with which to analyse socio-economic transitions. From the RIS perspective three narrower research problems were developed. Gaining insights into these narrower research problems provides better understandings of the broader problem statement above. These included three interrelated and nested research problems:

- The *first* is that there is little comprehension as to how ISs may enable or hamper socio-economic transitions to sustainability. There is little understanding or no detailed investigations that reveal the link between strong and functional ISs as having the required capacities to enable socio-economic transitions to sustainability. Furthermore, it is not known to what extent the capacities and capabilities of functional ISs may enable or have an advantage for both socio-economic and socio-technical change. In short, while it may be assumed that they do so, it is not known whether stronger ISs systems in fact can transition to sustainability more easily. Possibly there are other factors within strong and functional ISs that hamper STs in the socio-economy as well. However, a greater problem would be that weaker ISs do not have the ability or capabilities to transition to sustainability – which would require their being strengthened in regions globally.
- The *second* and narrower research problem proceeds on a different logic. Despite the functionality or strength of a system of innovation, is also how the direction of those ISs are determined. This may be multiple driving forces, or factors of influence. It may also vary from context to context. However, in this dissertation one position is assumed to be the problem area – that of socio-cognitive institutions. Little is known to which extent or how they may influence the trajectory of ISs. There is also not much known about the manner in which SCIs for sustainability are formed within and between the elements and mechanisms of ISs. In addition, if ISs are in fact found to be influential features driving and steering new directions within ISs – the wider problem again is how ISs themselves can be influenced, and influence ISs, to effect socio-economic transitions for sustainability.
- To narrow down the problem of socio-economic transitions to sustainability even further, the *third* research problem is about recognizing differences in contexts. This includes both scalar contexts and socio-structural contexts which are not spatially bound. Here the problem is about insufficient insights into how spatial factors and socio-structural factors like SCI are integrated and affect one another. Proximities are one way to develop a theoretical lens to link spatial distance and influences with other forms of proximity. Yet little is known about the link and dynamics of geographic spaces, and how these may influence the formation of SCIs for sustainability and spread within ISs to affect socio-economic transitions to sustainability on different structural levels.

On a final note, however, the broad research problem can be recognized as a complex social issue that extends beyond the control of any single solution. Yet individuals with strong socio-cognitive frameworks may influence (as will be discovered in the research findings). Socio-economic trajectories can be influenced even by individuals with strong socio-cognitive frameworks. As will be revealed in the findings, the leadership of individuals may be a key factor in the building and development of wider SCIs for sustainability. The research explored these possibilities.

Table 1. Summary of the research problem statements

The general problem statement can be summarized as: *Socio-economic pathways need to shift course to achieve sustainability, and there is little understanding of how SCIs within ISs may enable or hamper this shift.* **And more specifically:** *It is not known, to what extent weak or strong innovation systems may hamper or enable the ability of regions to transition to sustainability. However, while the strength and capabilities of ISs may provide the capabilities for STs it does not guarantee their direction towards a sustainability-orientation. Within the context of steering socio-economic systems, it is known that ISs play a big part of it. However, there is little or no understanding of the influence of socio-cognitive institutions for sustainability:* *a) within regional innovation systems (RIS);* *b) within and between different socio-structural levels in society; and* *c) and within and between different socio-spatial contexts.* *Finally, it is not yet known to what extent and how these may cause innovation systems to hamper or enable sustainability transitions.*

1.5.1 Propositions and research questions (RQs)

The broader 'problem' has been explored and discussed from a couple of viewpoints in this introduction section. At this point it is necessary to provide a summary of it and relate it to the narrower concerns described above that translate into research primary and sub-questions.

Innovation for sustainability is not yet a mainstream focus of driving socio-economic direction. The reason may be due to a lack of adequate policy measures and no fundamental understanding of what innovation for sustainability requires institutionally. The national or regional innovation 'systems' concept for understanding conventional innovation practices is

potentially a key to understanding how to direct the economy towards sustainability. Yet the subtle differences between conventional ISs and sustainability-oriented IS (SoIS) are not well understood. It is assumed through the research propositions that one of the primary differences is the qualities of SCIs embedded within ISs that determine their direction as sustainability-oriented or otherwise.

The continuation of unsustainable socio-economic development trajectories, when alternative possibilities of taking a more sustainable direction exist is a primary example of misdirected SCIs. Change in the orientation and functioning of ISs needs to take place before economic systems can transition towards sustainability. This change requires a fundamental shift in both formal and informal socio-cognitive institutions. The orientation of ISs could be understood as the systemic direction they take in terms of the collection of SCIs between its elements, mechanisms and the actors which constitute it.

From the STs literature it is known that governance, interventions and shocks at various socio-structural levels can lead to 'windows of opportunity' for innovations to diffuse in society (Geels & Schot 2010). These factors in themselves may reshape the SCIs of actors making up the ISs that produce the innovation to be adopted in the first place. It is proposed that it is the instability of socio-economic and institutional systems that is at least one possible cause of SCI shifts, as actors within ISs. Possibly, this is what results in new directions for innovation and for socio-economic development. Simultaneously it is assumed that the complex relationships and ties making up the ISs vary not only within and between socio-structural levels, but also across socio-spatial scales. These can be better understood as different forms of proximity leading to the extension, blocking (through lock-out of new SCI structures) or the formation and direction of novel SCIs.

The purpose of the two case study investigations of Austrian RIS and South African RIS are to assess these assumptions and propositions. It is also to provide a global perspective of a well-established sustainability-oriented RIS in a developed context; and a RIS within a developing context. These are investigated in order to answer the primary and secondary research questions below:

Table 2. Primary research question

Primary research question
How do SCIs within RISs constrain or enable pathways to socio-economic development for sustainability, in turn affecting socio-technical transitions to sustainability at different structural and scale levels?

The main research question is divided into three research sub-questions which are further distinguished in Part II into categories of enquiry for the content analysis (described in more detail in the introduction to research design below). In what follows, each research sub-question is associated with the proposition to be tested. For the purposes of the CA, each proposition is further divided into associated primary and secondary coding categories. The findings from the analysis of the case study data in each category systematically provide answers to aspects of the relevant sub-research question. These in turn contribute to the answer to the primary research question.

Table 3. Research questions associated with Theme I

RQs associated with Theme I – Capacity of regional innovation systems
Sub-Research Questions 1:
Sub-RQ1a:
Do strong and functional RISs have a greater capacity than weak ones to enable socio-economic transitions to sustainability?
Alternatively Sub-RQ1b:
Do weak RISs have less capacity to enable socio-economic transitions to sustainability?
Associated sub-propositions:
Sub-P1a:
Strong and functional RISs have a greater capacity to enable socio-economic transitions to sustainability.
Sub-P1b:
Weak RISs, have less capacity to produce and diffuse innovations, and hence enable socio-economic transitions to sustainability.

Table 4. Research questions associated with Theme II

RQs associated with Theme II – Socio-cognitive institutions and direction of RISs (i.e. SoIS)
Research Sub-questions 2:
RQ Sub-Q2a:
How do SCIs within RISs enable the direction and qualities of innovation outputs in the regional/local economy?
Alternatively RQ Sub-2b:
To what extent are SCIs a constraining factor on the development of SoISs, inhibiting them from creating pathways for socio-economic transitions?
Associated sub-propositions 2:
RQ Sub-P2a: *Socio-cognitive institutions are a primary enabling factor for determining the direction of innovation in RISs.*
RQ Sub-P2b: *Socio-cognitive institutions are a primary constraining factor for determining the direction of innovation in RISs.*

Table 5. Research questions associated with Theme III

RQs associated with Theme III – Multi-level structures and multi-scalar analysis in SCI formation
Sub-research question 3:
RQ Sub3: *How do socio-cognitive institutions develop and how are they shaped by various forms of proximities on different structural and scale levels?*
Associated sub-proposition:
Sub-P3a: *Socio-cognitive institutions develop and are shaped in different ways by various forms of proximities on different structural and scale levels.*
Sub0P3b?

1.6 Aims, objectives and investigative themes of this research study

This section continues from the research problem areas already explained above. Despite the obvious aim, which is to find answers to the research question and contribute to new knowledge, there are several other aims. There is one overarching aim and three secondary aims of this dissertation. Achieving these aims can have considerable influence on the approach to STs and ISs – both in theoretical communities and in policy circles. Thereafter each case study had its own aims designed to allow it to contribute to the empirical base on which the various findings were evidenced and discussions were centred. The research aims, were congruent not only with the three research problems described above, but become the broad investigative themes for the study, and inform the analysis frameworks that are applied

to the case study. Within the framework of these investigative themes, the aims and objectives of the study are discussed below:

- **Investigative theme I and first aim**: The first and broad aim of the study is to position IS theory within the context of socio-economic and socio-technical transitions to sustainability. Within this statement two further aims are integrated – the *first* is that while ISs have already been used as one of the theoretical approaches to STs, there is room for empirical evidence of its usefulness. The aim or objective of this study is to provide such empirical grounding for the importance of the ISs approach to STs. The *second* is that IS theory provides a detailed framework within which to assess and analyse the strengths, weaknesses and functionalities of RIS and their regional economies. This is useful for assessing the potential of regions or nations or sectors of the economy for that matter to transition to sustainability. In this context the aim is to use the RIS lens to assess which factors contribute to or hamper the ability of regions and regional (local) economies to shift towards more sustainable development trajectories. This is an important aim, which sets out to systematically reveal the stark contrasts in the institutional capabilities and capacities of RISs in both developed and developing world contexts. Here the aim is to use empirical case studies to discuss the differences in regional and local abilities to transition to SD. This investigative theme therefore, besides gearing towards answering the RQ's more generally, is aimed at revealing empirically how ISs can both become a useful tool for socio-economic and also socio-technical transitions. In other words, the aim is to show the links between changes in the wider economy and tangible socio-technical transitions. Assessing the strengths, weaknesses and innovative capabilities of regions through an IS lens could provide clues as to a region's ability to innovate. However it does not provide a measure of its willingness or intentions of becoming sustainability-oriented. The importance of understanding which factors determine the direction of socio-economies because of ISs and their ability to steer them, forms the second primary aim.
- **Investigative theme II:** The second aim is to comprehend which factors within the framework of RIS contribute to making that RIS or the RISs develop towards a sustainability-orientation. The aim is more specific in that it investigates more narrowly one factor that is assumed to make all the difference – that of sustainability-oriented SCIs. Sustainability-oriented SCIs, don't just exist they develop, and as

looser social groupings of shared cognitive frameworks eventually becoming cognitive institutions. The aim here is not only to gain a better understanding of how these SCIs for sustainability have developed within RISs over time, as in the Austrian case study but also what influences them and how to they formalize from being looser informal ideas. The aim of the South African case study is to track how SCIs can be developed and steered into a specific direction through visioning and strategy development as a localized process. The aim here is to investigate how informal institutions for sustainability may be formed at the local level. Whereas, formalized SCIs suggest the influence of RISs at a more aggregate level, SCIs for sustainability (driven by a new vision) may expand to impact the functioning and eventually the direction of ISs. Understanding this process is an aim of the Austrian case which is a benchmark study to better comprehend the South African case. For example, university research programmes for sustainability in collaboration with industry would constitute a powerfully formalized SCI that is sustainability-oriented. The aim of this investigation theme is to understand first of all what determines individual cognitive frameworks, and how they develop informally as institutions (as looser arrangements) and thereafter infiltrate innovation system structures as formalized SCIs for sustainability. It is thereafter an important aim or objective to try to better understand the link between these SCIs, and how they influence the direction of innovation outputs in the socio-economy and thereby also STs in regions. The case studies are to provide some empirical examples of this. The aim of the investigator was to unpack these findings, and discuss the implications thereof in the context of the literature on both ISs and STs. Each case represents different contexts and emphases on SCIs and ISs within socio-spatial scales and socio-structural levels. Gaining better insights between socio-spatial and socio-structural levels from an IS perspective is the focus of the third investigative theme.

- **Investigative theme III:** The third aim, and associated to this theme is to try to unpack and link both scalar perspectives and socio-structural perspectives within the framework of RIS dynamics. Various forms of proximities including cognitive, institutional, organizational, social can be related to spatial proximities. Here the aim is to use a theoretical lens based on the RIS literature to better comprehend the socio-spatial development of SCIs on different structural levels for sustainability. Socio-spatial factors are perceived to play an equally important role if not a greater role in

the formation and shaping of socio-cognitive institutions for sustainability than socio-structural influences. The aim here is to better understand how socio-cognitive institutional formation, socio-spatial and socio-structural levels can be related. The implications of which provide further insights into theory, but also practice. For example, the recognition and value of supporting spatially based pilot projects or spatial niche environments for sustainability – and the role of a regional/ local innovation system in this development.

The importance of new ways of thinking supporting alternative methods or technologies as a form of (socio-cognitive) institutional innovation has not had much attention in the literature. As the urgency to innovate for sustainability grows, the currently dominant SCIs shaping technology choices and development paths will be challenged insofar as they stand in the way of progress towards sustainability. Bringing about changes in SCIs so that they are able to 'overthrow' such old patterns of thinking and support a sustainability-orientation can profitably be viewed as a new form of institutional and social innovation. It is the aim of this dissertation to use the findings for further academic debate on the role of SCIs in ISs, and to what degree they constitute the key characteristic in sustainability-oriented innovation systems (SoIS). The implications for policy and for supporting new mechanisms to guide SCIs within ISs may have a substantial effect on the steering of economies towards sustainability.

1.7 Introduction to the case studies, research design and methods

1.7.1 Brief introduction to the case studies and findings

This study is deductive and qualitative in its investigation of two distinct case studies – one historical 'benchmark' study in Austria, and a contemporary study in South Africa. The aim of the case study research was to systematically analyse the data and findings through a content analysis (CA) framework developed to systematically answer the research questions. The analysis takes the time factor involved in STs into consideration for the Styrian case. This case is seen as a benchmark case of regional (partial) socio-economic transition to sustainability as well as isolated examples of socio-technical transitions to sustainability at the local level. The Styrian case can be regarded as a benchmark and historical study, because of the four decades during which SCIs have promoted first environmentalism and then sustainability. Evidence of the shift is marked by a strong socio-economic clean-tech sector,

and cluster called eco-world. The formation of this 'sustainability-oriented' sector in the regional economy is the primary validation of the research propositions. Yet there are several smaller examples, which show the link between SCIs, RIS, and socio-economic as well as socio-technical transitions to sustainability.

The other case is an 'embedded' case used in what was a recent study, called 'Transforming Technopark', at the time of this research. It was embedded because the specific spatial node, was not only spatially a part of the local innovation system (LIS) but also institutionally and structurally a part of the more aggregate regional and national systems[5]. This study provided good insights and learning about how SCIs can form, extend and formalize from a visioning and strategy development exercise for sustainability (of the park and the local Town of Stellenbosch). It provides insights into the possibilities for STs based on a developing situation, as a result of a transdisciplinary (TD) research intervention by the researcher. The researcher, who was embedded within the case as a TD researcher, provides an ethnographic report of the 'micro' dynamics of SCIs formation at the local spatial level. TD research still requires conventional methodologies, such as ethnographies. However, the context of the Transforming Technopark study, and the experience of the research was extended to the regional level which formed the boundary of the case.

It was not the aim of this study to compare the two case studies directly, but rather to cluster insights to answer the research questions from two differing contexts. The context of the Austrian case provided a benchmark from which to discuss the findings of the South African case. This was very useful at least to compare the differences in socio-spatial contexts within which each RIS had developed or was developing. The RIS of Styria state was well known, spoken about, functional and well-developed, while the RIS of the Western Cape was only being officially recognized at the time of the research. The latter case made for an excellent social and spatial arena for gaining insights into its development in which the researcher was heavily involved.

These two very different cases, however, when combining insights from the case findings provide substantial evidence for answering the RQs. Moreover, in the view of the researcher, they provide fascinating evidence of the role of SCIs within RIS, and how they guide local

[5] Technopark was zoned as a science and technology park, which forms part of both national and regional innovation system infrastructures; but are usually institutionally driven at the national, regional level and managed at the local level forming an important part of any IS

and regional economies towards sustainability. These findings, derived purely from an IS deductive analytical lens, are finally discussed in the context of ST literature. Further inductive categories are revealed through the analysis process which allows for richer discussions in the context of ST literature. These discussions in context of literature on STs reveal, and partially explore avenues for pioneering research in the ISs approach to STs.

1.7.2 The dissertation structure and research process

This research considers a large body of literature, relating to economic progress through innovation, but also the challenge and need for transitioning to sustainability. These bodies of literature come from divergent scientific paradigms, and rationales. The primary theoretical lens of this dissertation is the RIS, more specifically RIS internal elements and mechanisms that provide the theoretical perspective from which to investigate SCIs, and how they may influence socio-economic transitions to sustainability. In the final part of the dissertation, these findings are compared to the literature on STs to provide a rich discussion on the case study findings.

The dissertation is divided into four distinct parts, which are explained below. The research design and process is also briefly introduced below – which will be explained in greater detail in Part II of this dissertation. Figure 1.1 depicts how the research processes, and how the different theoretical and analytical parts form a synthesis of the argument.

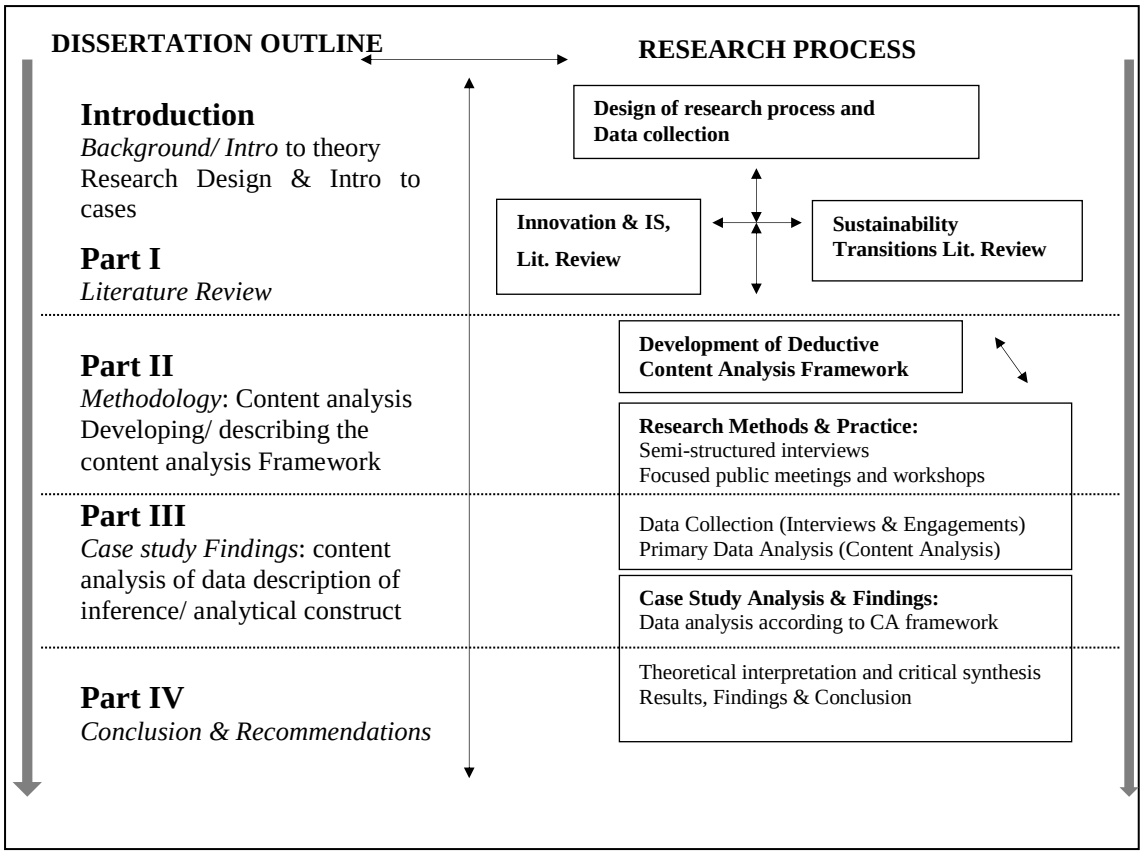

Figure 1.1 Diagrammatic description of the dissertation and research process

Introduction: The research rationale is developed throughout the introduction section and presented at its end. It is developed as the need for a better understanding of how socio-economic transitions to sustainability can be achieved. Furthermore, the research questions are developed within narrow problem framings, and the various investigative themes of the research are systematically presented. There is a brief introduction to theoretical concepts and the main theories, the aims of the study, and the literature focus and review. The design of the research and the methodology and the methods chosen, including a short description of the case studies, are outlined.

Part I – Literature review: A comprehensive review of the literature on innovation, innovation systems and sustainability transitions is presented with an eye to its relevance to the research problem. The main focus is on RIS theory, as the primary lens of investigation. The aim of Part I of the dissertation is to create a strong theoretical foundation for the analysis and critical discussions.

Part II – The Development of a 'deductive content analysis framework': This part is divided into two sections. The first is designed to synthesize the theoretical themes from the

literature review with a view to its relevance to the three investigative themes. However, additional theoretical perspectives are included to provide additional analytical conceptions for each investigative theme. The second section deals in detail with the methods used in the analysis, and shows the link between the literature review and the CA framework. This proved useful for linking the findings from the case studies to the literature. This is also where the CA, methodology and design are described. It is the primary methodological framework for application and presentation of the findings in Part III.

Part III – Case studies, analysis and findings: This section introduces and contextualizes the case studies, before analysing them in the established CA framework. Findings are derived first through application of the deductive CA codes, from the literature. Thereafter inductive codes are clustered for each case study. The findings are presented as an ethnographic narrative, from the perspective of the researcher. However, evidence from the cases as findings for the research questions are not only interwoven into the perspectives, but provided as direct quotes from the respondents. The insights gained from the inductive categories are left for the discussion section where the answers to the RQs are critically discussed in context of literature on STs.

Part IV – Discussions, conclusion and recommendations: It is here where the dissertation's findings for the RQs are discussed in context of STs. The inductive findings provide new insights into both IS theory and ST theory. A strong academic voice and opinion of the researcher is developed in this final section about the ISs approach to STs. Key assumptions are revealed in some cases to be accurate, and in other cases not. The propositions and research questions are used to guide the discussion points. Several recommendations are made for new research avenues – most notably from the perspective of ISs for socio-economic transitions.

1.7.3 Dissertation orientation map

As is introduced below, a diagrammatic summary and description of each part is given to assist the reader in following where they are in the context of the dissertation. This will be provided at the beginning of each subsequent part of the dissertation. Due to the length of the dissertation, this guide aids the reader in reminding them, through a highlighted portion of text where they are in the dissertation's argument and context. It also provides a summary and serves to highlight the key aims or objectives of each chapter. Below is a diagrammatic example of the template that is used.

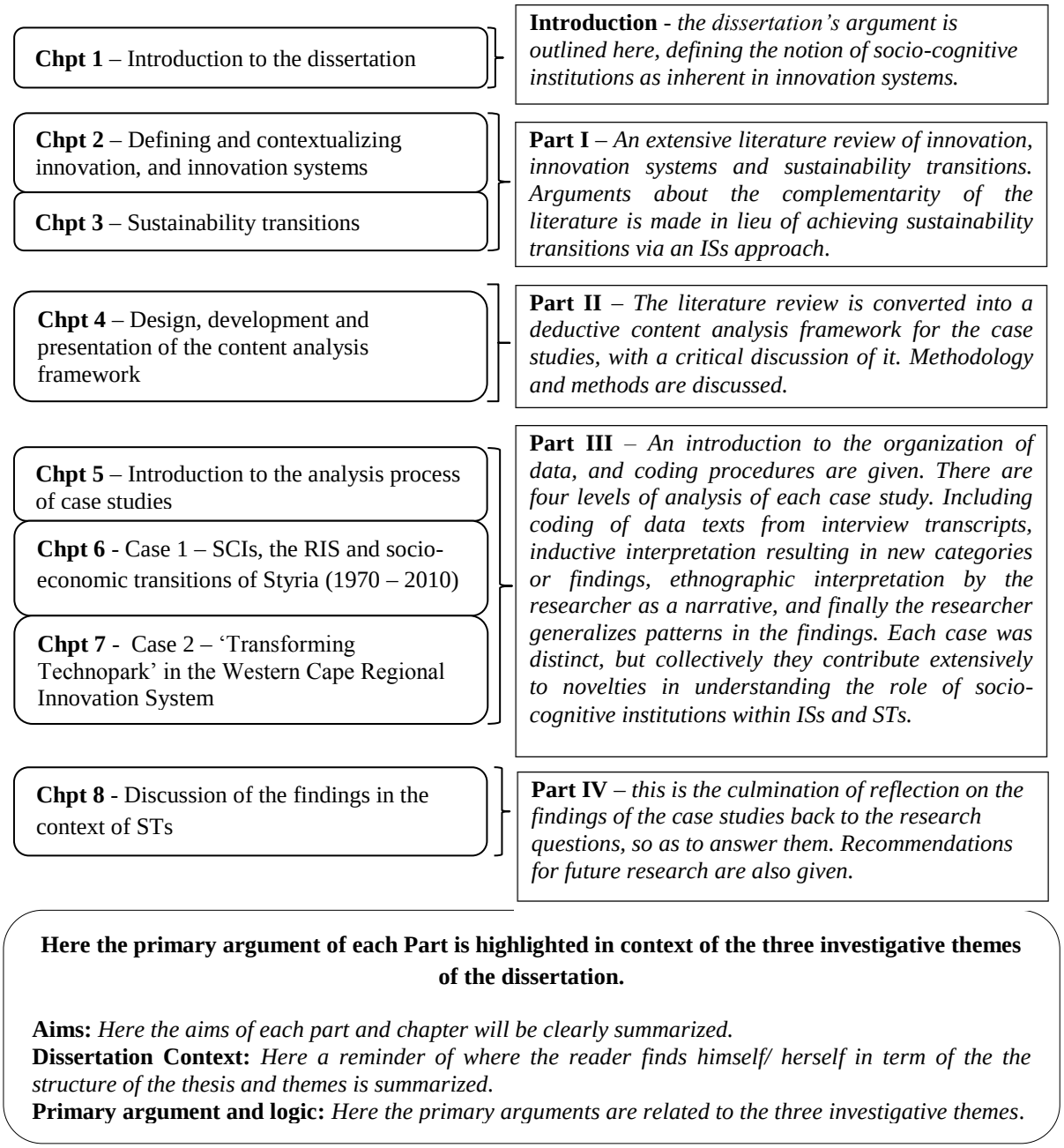

Figure 1.2 Example of the dissertation orientation map

1.7.4 Methodological approaches and methods used in this study

This study employed a mixed methods approach, in both the design of various data collection methods and in the analysis of that data. In the first instance the case study method was employed to investigate two distinct cases as described above. While the research process and investigation began with the Stellenbosch case, it was interrupted by including a 'benchmark' study that became the second case, or the Austrian case. The aim of which was to compare the findings of the South African case with a recognized and well established sustainability-

oriented RIS. However, it was also done to gain retrospective insights into the South African case, upon returning, when the researcher continued the ethnography.

The South African case was in fact, an embedded case study with two distinct, yet connected parts. These two parts represent the more 'designed' research processes, which included interviews of key actors in the RIS, and at the local level. The first aspect of the case, was embedded within the regional innovation system of the Western Cape Province (W.C. RIS) and strictly speaking also within the Stellenbosch local innovation system (LIS). This aspect of the case was dubbed the 'Transforming Technopark' project. The other aspect was the involvement of the researcher in assisting regional actors to understand, gain insights into and produce a research report to guide the W.C. RIS. Although these two parts of the case were separate research processes, they were not necessarily separate cases. They were intricately connected, and the 'spatially' narrower Stellenbosch and Technopark part of the case was certainly embedded and influenced by the W.C. RIS.

In both cases, the researcher employed an ethnographic perspective and methodology during the data collection process. This was true to a lesser extent in the Austrian case, because the researcher was not involved in a contemporary study (it was more of a historical study), and was not actively trying to influence or co-develop any 'outcome'. However, in the South African case, the opposite was true. The researcher had in fact designed the case, with his own involvement in it as a 'transdisciplinary' process. This required the researcher and a set of actors in the local innovation system (LIS) of Stellenbosch, to co-develop a vision and strategy for the local Technopark. Once the vision was established and the strategy set, the transdisciplinary aspect of the case continued with the involvement of the researcher in the case after the Austrian study had been completed. This allowed for an interesting emic, or insider perspective, approach to analysing the South African case. In parallel and as part of the TD research process, data was collected through a more structured and rigid process of workshops, focus groups and interviews. These more formal data collection techniques allowed the researcher to use triangulation to validate the claims made or experiences described in the ethnographic account.

Content analysis was the means to ensure some objectivity and reliability in the systematic analysis of the data that was derived. The CA technique allows the researcher to develop various coding categories from the literature and with the aid of a computer program (MaxQDA) to extract bits and pieces of information from the transcribed interviews. These

data units are in the form of sentences, paragraphs or key-words that are extracted to support the researcher's claims. However, in the analysis it remained important to recognise the context of the derived data, which included the context within which the data was created. It also included the perspective of the researcher who was present during the data generation period.

1.7.5 Validation of the research findings

Validation of many of the claims made by the researcher could be determined through factual and in most cases clear evidence of the existence of phenomena, that was referred to in the text. For example, in the Austrian case, the existence of 'eco-world' as a clean-technology cluster was easily validated through searching for its existence on the internet, or by going there. In the South African case, this was more important, as the 'effects' of the TD intervention lead to a series of events, and actions that could be directly related and traced to the 'Transforming Technopark' case. These external validations served as important confirmations of the findings, and also the claims made by the researcher. For example, the 'Stellenbosch Innovation District' (SID) programme, which was initiated as a result of the TD research process, and the formalization of the Technopark Owners Association (TPOA) into a formal management structure, which adopted the recommendations for both vision and that emerged from the TP research process in which the researcher was directly involved. The internal validation of the findings was determined through the interviews, and in findings overlaps and patterns of different respondents. Validation of the research was effected through the triangulation of the researcher's perspective, the interview data, and what existed in reality.

1.7.6 Research ethics and informed consent

The researcher gained ethical clearance for both cases from the Stellenbosch University Ethics committee. The nature of the research was regarded as similar in both cases, and no substantial changes to the ethical procedures or rules took place (A letter for ethical clearance in the Appendix A2). Ethical clearance for the study after review was gained on the 25th March 2011, and for the Austrian case this was reviewed and gained in 2012.

Each interviewee or organization was required to complete and sign the 'informed' consent to signal their permission for the relevant data to be used in the research study. These forms as well as the raw data, as stipulated in the ethics committee rules, are kept in a safe and secure place for a period of two years after the research was completed.

The researcher followed the guidelines for ethical research procedures as stipulated for qualitative research in the humanities, and the Faculty of Economic and Management Sciences at Stellenbosch University. The following ethical procedures were followed and decided upon to protect the research subjects:

- Permission was gained from the Technopark Owners Association for the interviews to be conducted on their premises (i.e. Technopark).
- A letter of support was obtained from ISIS, Karl-Franzens University (KFU) for conducting research in Styria province, Austria.
- It was decided that all individuals or organizations would not be named directly, but rather referred to as a code. (E.g. Firm 'A' or Academic 'B'). This was to protect the anonymity of individual or organization.
- It was made clear at the start of the research that no subject will be remunerated for his or her participation in the interviews or focus groups.

It was agreed, that the research results would be shared with the interviewees and organizations that were involved. This was to further ensure public validity, to enhance the trustworthiness of the research and to contribute to their own knowledge.

1.8 Research rationale and research contribution

1.8.1 Intended audience, scope and limitations of the research work

The intended audience ranges from theoreticians, researchers and academics to innovation systems policy-makers and project managers working on sustainability transitions. Each case study has contributed to an understanding of innovation systems, in Styria (Austria) and Western Cape (South Africa), and their potential to contribute to sustainability transitions for the local and regional governments.

The study aims to make theoretical and practical contributions. The theoretical project has clear limits. Bringing together the bodies of theory on innovation, innovation systems and sustainability transitions is a task only begun here. Taking it further and exploring its implications is an intellectual project calling for much future work. However, this study makes an important and pioneering contribution to this new research direction. Although an extensive literature review was undertaken and a broad range of literature is referred to, only a small number of the theories could be used as a lens during the investigation. Through the investigation, insights are generated to influence new directions for theory development.

The practical aspect of the work is limited to two case studies, chosen purposefully to provide empirical insights from two divergent contexts. The Austrian transition landscape and innovation environment differs extensively from the South African. This project can only start to investigate the theme of 'socio-cognitive institutions' in ISs, but recognises the many other factors besides SCIs that may influence the trajectory of socio-economic development. However, the view taken in this research is that it is often external events or pressures that influence SCIs – but it is from SCIs frameworks in RIS that actors act. Therefore, it is very interesting to know, discover and investigate what these SCIs are, and how they may differ not only between different structural and scale levels in one geography, but across geographies of the world. Hence there was a choice of utilizing a developed country as a case study, to bring additional perspectives to the developing country findings.

The limitations of the study and the various assumptions made are recognized. It is important to highlight these here, so that a better understanding of the scope and approach to the research is gained. From a literary perspective, the study was limited to a regional innovation systems (RIS) perspective. It could be argued that the study could have included a wider aggregation such as the NIS perspective. Secondly, it could be argued that the researcher should have included sets of literature that deal with social and organizational change. However, this was not possible in a study focused on regional and local levels. The concern was more about inter (between elements) – than intra (within elements or organizations).

There were considerable challenges faced in doing the research, which are expected in doing TD research and moreover 'participatory' ethnographic research. The primary challenge to the researcher was in getting participants to comprehend the purpose and benefit of the research to them – in the end this was achieved. It also signals a triumph for TD research, as tangible outcomes were achieved and bought into by stakeholders due to the research being conducted as a participatory process.

On a more practical research level the researcher was not able to conduct a comprehensive TD research such as is possible when a larger group of 'academic' actors form part of the TD team. Limited resources and the novel approach of doing TD research as a single researcher was very challenging for the researcher. Despite these limits on the research, substantial progress was made. This was done via using a visioning process, and finding common challenges to bring actors together, who positively contributed to the research process.

1.8.2 The theoretical contribution of the research

In the academic field of ISs research, the gap in understanding ISs as tools, or policy guidance mechanisms for socio-economic and socio-technical transitions for sustainability is a matter of concern. This dissertation aims to narrow that gap, by providing a specific academic view on what distinguishes conventional innovation systems from sustainability-oriented ones. The concept of SoIS, although used for the first time by this author, is for the first time discussed from a socio-cognitive perspective. The dissertation also provides a novel approach to case studies. Until now, there has been a limited understanding of the concept of a SoIS, and what it actually is, or how it functions. The insights offered by this study are perceived as a significant contribution to theory that opens many new avenues for research and theory development in the context of sustainability transitions. Furthermore, probably the largest contribution here is the distinction between socio-economic transitions and socio-technical transitions. From the perspective of the author a SoIS is suited to both, and again opens up several pathways for academic enquiry into socio-economic transitions to sustainability.

These case studies may provide valuable insights for theory development in both innovation systems and STs. Building on RIS theory through a better understanding of the role of socio-cognitive institutions in and between the elements and internal mechanisms of innovation systems provides a starting point for developing theory of sustainability-oriented innovation systems. The subtleties of socio-spatial contexts cannot be neglected in this debate. At the same time, it should be remembered that these topics are broad, and the investigation in this dissertation provides only a starting point for further investigation. That is not to underestimate its significance. The attempt is worthwhile in the wider context of the sustainable development and sustainability transitions debate, as it is clear the role of all forms of innovation, especially 'system innovation', is critical.

1.8.3 The practical contribution of the research

The practical contribution of the research on the South African and Austrian case studies is different. Together, however, they contribute to policy development for sustainability transitions on a global level.

As a direct consequence of the case study, which was an 'intervention' through research, Stellenbosch University was mandated to drive a project called the Stellenbosch Innovation District (SID). SID was formally sponsored by the Department of Science and Technology

(DST) to assess the feasibility of transforming Technopark and the town into an innovation district. It remains an on-going project with involvement from Stellenbosch University, the local municipality, and big business leadership. Furthermore, as a result of the case study, the local Technopark has recently become a special ratings area (SRA), which makes it possible to be managed independently. However, this new legal entity seeks to become a 3-helix entity to ensure collaboration towards the vision and strategy that was created through the research process. This is: 'To enable and create a vibrant, sustainable and innovative business community' in Technopark. The researcher remained involved in both these processes on an advisory level at the time of writing the disseration.

It is important to note that the five-year research period and the involvement of the researcher in the local innovation system community (as both a TD researcher and in doing the ethnography), made it possible for a longitudinal perspective on the initial case study intervention (i.e. TTP). This was also useful as evidence of the research having a practical influence on the LIS of Stellenbosch. The primary objective of the case study was more in line with 'contemporary transitions' and 'visioning' than a retrospective case study. The time-period of the practical investigation was between 2010 and 2011; however, the researcher remained 'ethnographically' involved and continued to influence the process there as a 'research consultant' until 2014.

The researcher involvement in the Austrian case was not as intense, because it was regarded as a 'benchmark study' and as a historical case. The aim was to gather data and evidence of a well-established sustainability-oriented innovation system, developed over four decades. However, how it functioned at the time of the research was also relevant, which was between 2011 and 2012. The existence of the eco-world clean-tech cluster is regarded as an outcome of the regional innovation system of Styria having a sustainability-orientation. Eco-world and the interaction with it involved engagement between various actors, organizations and institutions such as firms, research centres, universities and government agencies. The researcher gained a fair degree of emic or insider perspective in being involved in many of the Eco-world, activities, events and conferences etc. The results of the study provide useful knowledge for the actors and organizations making up the case; but also for the leadership of the regional government; other researchers and policy makers.

PART 1 – *Chapters 2 and 3*

Exploration of the literature on innovation, innovation systems and sustainability transitions

Chpt 1 – Introduction to the dissertation

Introduction - *the dissertation's argument is outlined here, defining the notion of socio-cognitive institutions as inherent in innovation systems.*

Chpt 2 – Defining and contextualizing innovation, and innovation systems

Chpt 3 – Sustainability transitions

Part I – *An extensive literature review of innovation, innovation systems and sustainability transitions. Arguments about the complementarity of the literature is made in lieu of achieving sustainability transitions via an ISs approach.*

Chpt 4 – Design, development and presentation of the content analysis framework

Part II – *The literature review is converted into a deductive content analysis framework for the case studies, with a critical discussion of it. Methodology and methods are discussed.*

Chpt 5 – Introduction to the analysis process of case studies

Chpt 6 - Case 1 – SCIs, the RIS and socio-economic transitions of Styria (1970 – 2010)

Chpt 7 - Case 2 – 'Transforming Technopark' in the Western Cape Regional Innovation System

Part III – *An introduction to the organization of data, and coding procedures are given. There are four levels of analysis of each case study. Including coding of data texts from interview transcripts, inductive interpretation resulting in new categories or findings, ethnographic interpretation by the researcher as a narrative, and finally the researcher generalizes patterns in the findings. Each case was distinct, but collectively they contribute extensively to novelties in understanding the role of socio-cognitive institutions within ISs and STs.*

Chpt 8 - Discussion of the findings in the context of STs

Part IV – *this is the culmination of reflection on the findings of the case studies back to the research questions, so as to answer them. Recommendations for future research are also given.*

Part I - Chapters 2 & 3

Context in dissertation: *Here extensive literature reviews on innovation, innovation systems and sustainability transitions are required to contextualize the whole debate about how socio-cognitive institutions are an intricate part of innovation systems functioning and directions.*
Aims: *To provide the theoretical basis for discussion of an innovation systems approach to sustainability transitions. But also to provide a theoretical base for establishing a content analysis framework for the empirical case study analysis in Part II.*
Primary argument and logic: *It is argued through-out, but more specifically towards the end of Part I, that innovation systems theory has considerable value in better understanding and managing transitions to sustainability. Furthermore, the conceptual frameworks of RIS, and forms of proximity provide an excellent theoretical conduit with which to better comprehend the enablement and constraint of socio-cognitive institutions favouring sustainability or not. Upon critical reflection it is argued here that ISs and STs theories can and should be more intricately woven for building capacity for sustainable development.*

Dissertation orientation for Part I

In a rapidly changing and unequal world with an unsustainable trajectory, rethinking production and enhancing the factors that produce and distribute more sustainable outcomes through innovation is pressingly urgent. The capacity and functioning of ISs interacting with production systems are key to achieving competitiveness in the economy. However, the influences of the direction and technological pathways created by ISs are more important in achieving sustainable business, economic and societal transitions. ISs guide the direction of technological and social development, and, in the medium and longer term, the direction of the economy. In developing them, business, government, academia and society all have a role to play in co-creating, supplying and demanding the right set of factors for transitions to greener development and economic growth paths.

The literature review starts with a brief history of innovation and ISs and their development as a prominent, emerging focus of study. It first explores theorizing about innovation, ISs and STs, examining their elements, mechanisms and dynamics as described by various authors, then undertakes a more detailed review of RISs. Thereafter a substantial review of sustainability transition from a historical and a contemporary perspective is provided. This is necessary for critical discussions of the case-study, but does not form part of the literary deductive framework of the content analysis (CA) as described in the introduction.

Innovation was for a long time understood as a relatively static and linear process. The review first explores how this understanding has changed to encompass more complex interactions in ISs. Despite its importance, the concept of 'socio-cognitive' is used very sparsely in the IS and ST literature. Discussing it in the context of RISs allows its significance to become plain. The aim of the literature review is to provide a rich understanding of RIS dynamics at different levels of scale and structure. RISs in the context of STs are used as the theoretical focus of the analytical framework for the case studies. An in-depth understanding of RISs, however, requires a review of the theory from which the concept partly originates: innovation theory and NIS theory. A better understanding of RISs is also gained in relation to the related concepts of sectoral innovation systems (SISs) and technological innovation systems (TISs). Although these perspectives are not the primary focus of the review, they provide insights into the theoretical framework for analysis of the case studies.

The primary aim of the literature review is to refine the definition of the research problem: to give insights into the dynamics of ISs and how these relate to SCIs that enable or hamper STs. Influence also flows the other way. The empirical research both draws on the various fields in integrated ways to interpret and highlights the gaps in the literature. New insights are produced, augmenting current theory and promoting alternative directions for it.

2 CHAPTER 2 - Defining and contextualizing innovation, and innovation systems

Innovation is an important element in economic growth theory. In the global context of the shift from the industrial era to the information era, innovation has become crucial to economic success and development. It is a defining feature of the modern knowledge economy. A nation or region's competitiveness in the global 'knowledge economy paradigm' is now measured by its ability to innovate, learn and unlearn[6] (Castells, Hall & Hall 1994; Harmaakorpi 2004; Rutten & Boekema 2007).

The term ''innovation'' is widely used, but with a variety of meanings. These have emerged over the last few decades as the concept has been developed in different contexts and scholarly projects, and more recently in different cognitive communities (Fagerberg, Fosaas, & Sapprasert 2012). For our purposes, innovation cannot be separated from context. The current context that should be driving innovation is the urgent need to transition from unsustainable socio-technical systems to more sustainable ones. Yet innovation as a concept remains to be associated in a positive manner with economic growth, profit and development without limits.

In the next section, the major contributors to innovation theory are discussed with a view to suggesting how the understanding and context of innovation has developed.

2.1 The classical contributors to innovation theory

In their review of the emergence of innovation studies, Fagerberg (2003), Fagerberg and Verspagen (2009) and Fagerberg, Fosaas, *et al.* (2012), point to the large number of contributors to the scientific field of innovation.

Joseph Schumpeter (1883- 1950), one of the most influential authors in innovation studies, was *avant-garde* in his insistence that innovation was the key to 'economic evolution' or development. He was opposed to what he considered the almost static model of neo-classical economics that rested on the assumption of *ceteris paribus* (all other things being equal). In reality all other things are not equal, and neo-classical economics often reduces the complexity and dynamism of economic processes in unhelpful ways. Schumpeter understood

[6] The concept of 'unlearning' is important. It conveys the ability and flexibility of nations or regions to innovate in the sense of leaving received wisdom and adopting new 'ways' and means of producing outcomes.

this and promoted the idea of innovation and entrepreneurship as a central dynamic in economic systems, leading to an evolutionary process of business cycles. For him, economic development occurred in cycles of 'creative destruction' where new technologies and ideas disrupted and replaced old, redundant or less favourable technologies or solutions. This was achieved through innovative individuals and entrepreneurs, who interacted with what he called 'inert social environments'. Later the role of research and development (R&D) was included as an important driver of innovation. These concepts were central to his work, *The theory of economic development* (Schumpeter [1934] 2012). The later term *'evolutionary economics'* describes the scientific field and academic community that endeavours to uphold and develop Schumpeterian thought. Andersen (2009) gives a substantial review of Schumpeter's work.

At the time of Schumpeter's death, statistical and econometric approaches to economics were overwhelmingly popular. He admired these approaches, but complemented them with an historical view of economic progress. The statistical and econometric approaches were soon modified as economists started realizing their academic limitations in describing long-run economic development. Thus, during the 1960s, there was a revival of Schumpeter's descriptive or historical approach to understanding innovation in economic activity. Among other things, this ushered in the US Air Force's focus on research and development (RAND): a response to the understanding that innovation and technology development was critical to maintaining the US's global technological dominance in both economic and military terms during the cold war (Fagerberg & Verspagen 2009).

Innovation studies are an interdisciplinary field. An aspect which has had attention from sociologists is the spread of innovations in society. Rogers, in his prominent work *Diffusion of innovation,* was a pioneer in his explanation of how innovations are accepted in society, and how they take-off, mature and eventually wane or fade out (Rogers *et al.* 2009; Rogers 1983).

Richard Nelson, linked to the RAND research institute edited *The rate and direction of inventive activity* (Nelson 1962). This sparked an array of research looking into the field of innovation, and sub-categories such as sources of invention, the effects of R&D on industry, and the elements that underpin the production of new knowledge (Fagerberg & Verspagen 2009).

The UK-based Science Policy and Research Unit (SPRU) paved the way for innovation studies in Europe, using a multi-disciplinary approach. It produced some of the most prominent names in innovation studies. SPRU Director Chris Freeman's book, *Unemployment and technical innovation*, was one of the first to adopt a systemic view of innovation (Freeman, Clark & Soete, 1982). Richard Nelson and Sidney Winter augmented this in their book, *An evolutionary theory of economic change* (1982). They drew attention to the 'inseparable' link between innovation and economic development. This built on the Schumpeterian interest in long run economic change, giving a more detailed description of the 'micro-foundations' of economic growth and emphasised the importance of knowledge in organizations, the heterogeneity of institutions and their interactions (Fagerberg, Landström & Martin 2012; Martin 2012). These insights set the scene for modern innovation theory, as knowledge, interactions and institutions remain key elements in innovation theory and the most modern theories of ISs.

Another author who paved the way for new directions in innovation studies was Nathan Rosenberg (1976, 1982), an economic historian. He was one of the first to look at innovation from a systemic point of view, an approach which other authors such as Freeman built on. His work on innovation in relation to technology and economic development through institutional change was pivotal to understanding innovation processes (Fagerberg *et al.* 2010). It also became central to theory on innovation as a system rather than as a linear process of inputs (usually R&D) that lead to eventual innovation outputs and uptake in the market.

Keith Pavitt (1984) explored the ways in which innovation operated between different sectors of the economy and between industries (Fagerberg, Fosaas *et al.* 2012). Lastly, Chris Freeman (1987), Bengt-Åke Lundvall (1992) and Richard R. Nelson (1993) all contributed significantly to the theory of national systems of innovation. The innovation systems approach favours a more holistic way of analysing the various institutional and organizational factors and interactions that lead to innovation on a macro scale.

Finally, it is useful to obtain a sense of the various formal 'cognitive communities' that have emerged around the subject of innovation. Fagerberg and Verspagen (2009:227) comment:

> Scholarly inspiration turns out to be an important feature in delimiting these communities. Apart from Schumpeter, the 'founding father' of this body of knowledge, who is highly appreciated by almost everybody (with the exception of the small 'Management' cluster), most sources of inspiration tend to be valued highly by one or a few clusters only. For instance, the 'Schumpeter Crowd' is closely associated

> with Nelson, Freeman and Dosi, the 'Geography and Policy' community with Porter and Lundvall and the 'Periphery' and 'Industrial Economics' communities with Griliches.

Freeman (1974 & 1982), Freeman and Soete (1997), Nelson and Winter (1977), Dosi (1988), Griliches (1990), and Brown and Eisenhardt (1995) have tried to define the field of innovation studies through reviews of the literature. Other contributions have been made by Fagerberg (2003), Fagerberg *et al.* (2006), Fagerberg and Verspagen (2009) and, most recently, Fagerberg *et al.* (2010) in the *Oxford handbook of innovation* and Wesley Cohen (2010) in the *Handbook of the economics of innovation* (Hall & Rosenberg, 2009). Nevertheless, Martin (2012) notes the lack of a comprehensive and quantitative review of the field of innovation studies to date. His article, along with those by several other authors in a 2012 special issue of *Research Policy*, goes some way towards filling the gap. Martin's paper, 'The evolution of science policy and innovation studies', examines the potential for science policy and innovation studies (SPIS) to become a formal discipline after 50 years of contributions to the field. The special issue not only recognises the need to map past work in innovation studies, but discusses the emergence and convergence of new and differing fields of research as related to knowledge, innovation and the economy (Fagerberg, Fosaas *et al.* 2012; Fagerberg, Landström *et al.* 2012). These contributions confirm the emergence of innovation studies as a scientific field.

2.2 Definitions, context and factors of innovation

The word *innovation* is common enough, but its meaning and significance are not as easily pinned down. This sub-section briefly explains it and related terms as they are used in this dissertation, and discusses some of the ways in which it may be measured. The way in which innovation is measured is important, because it provides clues as to what is regarded as central to innovation: a set of inputs and outputs. These may include patents, spending on R&D, and the number of journal articles or PhDs produced per year. This assessment is useful in understanding how a community or policy maker values innovation and also recognises it.

The Oslo Manual of the Organisation for Economic cooperation and Development (OECD) provides the most widely used definition of innovation:

> An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations.
>
> (OECD 2005)

The most important element distinguishing an innovation from an invention is that an innovation is something implemented. This means that it needs to be in use, either in a firm or organisation, or sold in a market. However, innovation goes beyond being simply a new product or technology. It can be seen as a process determined by a number of general and specific contextual factors in certain socio-technical environments that may lead to a new or improved product, service, organizational form or social institution. Below are some general descriptions and definitions of different forms of innovation used in the South African Innovation Survey conducted by the Human Sciences Research Council (HSRC) of South Africa in 2005 and in 2008. They are aligned with the OECD definitions of innovation (HSRC 2011:176-179).

The survey distinguishes four types of innovation:

> ***Product Innovation*:** is related to products or services and refers to when a new good or service is introduced to a firm or market. It also may refer to the radical or incremental improvement of a certain product or service.
>
> ***Process Innovation*** refers to changes or improvements in processes. This includes production methods, delivery methods or distribution methods.
>
> ***Organizational Innovation*** refers to the restructuring of the firm's organizational functioning. This includes workplace organization, and innovative management designed to increase the innovativeness of the firm.
>
> ***Marketing Innovation*** refers to significant changes in sales and marketing methods. This includes design and packaging to enhance consumer appeal.
>
> (HSRC 2011:6)

Innovations can also be classified in different delineations or markets. The South African Innovation Survey uses the following categories:

- Innovations as new to the firm;
- Innovations that are new to the market of the firm (and competitors);
- Innovations that are new to a country (e.g. South Africa);
- Innovations that are a world first.

(HSRC 2011:6)

It is evident that the definitions of innovation and its measurement used in the SA innovation survey are orientated primarily to economic growth and business. That is to be expected. Tangible items such as patents, or new processes or money spent on research and development (R&D) are easier to measure and compare. They can be classified as formal

innovation activity. However, informal innovation activities such as networking, and sharing experiences and knowledge, although difficult to measure, often form a vital part of the innovation process (Blankley, Scerri, Molotja, & Saloojee 2006; Lundvall, Joseph, Vang, & Chaminade 2009; M. Rogers 1998).

These definitions also cover inter- and intra-firm innovations, primarily in the business environment and based on a Eurocentric template and the first world OECD recommendations of the Oslo Manual[7]. The Oslo Manual was developed in 1992 as a set of guidelines for innovation surveys in OECD countries, so as to ensure comparability between results in different nations. It has been periodically revised, as contributors to the manual recognise that understanding and measuring innovation is an on-going process with much still to be discovered. More recently, the manual has been used for comparisons by non-OECD developing countries as well (Blankley *et al.* 2006). The most important emphasis in the latest edition of the manual is the focus on 'linkages'. This reflects the importance of a systems approach to understanding innovation:

> Evaluation of linkages is expanded because of the importance of knowledge flows among firms and other organizations for the development and diffusion of innovations. This helps to highlight the role of organizational structures and practices that promote the sharing and use of knowledge and interaction with other firms and public research institutions.
>
> (OECD 2005)

Innovation and its definitions should not, however, be left up to the interpretation of governments and transnational organizations like the OECD alone. Business adds another perspective, as does organised society. There is a wealth of literature explaining not only the measurement of innovation, but also its importance in different contexts. See, for example, the overview given by Blankley *et al.* (2006).

Choosing how to define and how to measure innovation may have far reaching effects (both positively and negatively) on the total innovation focus and economic outcomes of a region or a nation. For this reason, the concept of innovation and its meaning in a specific context should be carefully considered. This caution should especially be heeded in debates about innovation policy at regional and national levels as it has an effect on efforts to organise the factors determining innovation in those contexts. What is quite certain is that knowledge and

[7] The methodology used in the South African innovation surveys of 2005/2008 (HSRC 2011) was directly comparable to the CIS4 for EU countries, and was based on the guidelines of the Oslo Manual (OECD 2005). The rationale behind using this template and methodology is that it makes comparisons possible.

its transfer into useable applications in society is core to innovation. In the words of the Oslo Manual:

> Innovation activities are all scientific, technological, organizational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations. Some innovation activities are themselves innovative, others are not novel activities but are necessary for the implementation of innovations. Innovation activities also include R&D that is not directly related to the development of a specific innovation.
>
> (OECD 2005:47)

The two most obvious contextual differences for defining and measuring innovation are between different countries and their levels of development. Less obvious differences are the purpose or macro-level goals of innovation: innovation purely for the sake of competitiveness and economic growth, or innovation for sustainable development as a new paradigm. Defining innovation as a concept is important to inform arguments later in this document. However, this dissertation is primarily concerned with understanding innovation as a systemic and institutional process, or what is described in the Oslo Manual as a set of 'linkages'. This gives prominence to the focus on what drives innovation in different contexts (eg institutional and systemic factors in proximity), as well as the rationale for understanding innovation as a result of a system of institutional and organizational linkages.

2.3 What are the factors conducive to or driving innovation?

In his work on diffusion, Rogers (1983) dedicates some attention to understanding what drives innovation. His model covers the 'system' out of which the innovation emerges in the first place, the way the production process has been handled, the eventual diffusion of the innovation, and even the 'consequences' of the innovation. This he labels the *innovation-development process.* It consists of:

> …all the decisions, activities, and their impacts that occur from recognition of a need or problem, through research development, and commercialization of an innovation, through diffusion and adoption of the innovation by users, to its consequences.
>
> (Rogers 1983: 161)

What is interesting here is that Rogers, (1983) talks about the pre-innovation process as well as the diffusion or post innovation process. Innovation systems involve these pre- and post-innovation processes as well as innovation itself. Alongside attention to the general development process of innovation, there has recently been a lot of work on what drives innovation on different aggregate levels, from nations, to regions, to firms.

This broadens our understanding of what makes for a successful innovation culture and environment. Even at this level, a narrow focus has to be avoided. For example, focusing on innovation at the firm or corporate level is important, because much innovation activity takes place there. However, the environment in which a firm is able to innovate through establishing linkages and capitalise on its innovation for the benefit of society or economic growth is as important (West 2001). Firm level innovation itself does not fall within the scope of this study, but innovation at the firm level is viewed as a symptom of the ability of that firm to capitalize on its external environment and availability of resources. No doubt, however, this ability is only as good as the internal capabilities of agents within the firm or organization: what is discussed later as 'cognitive proximity'. Although there is no golden formula to determine which factors are necessary to drive innovation in particular environments, certain components (like firms or universities), elements and critical factors, are usually present. These terms need clarifying. They are closely related, but describe the characteristics of innovation from different perspectives, as reflected in different bodies of literature. All three terms will be used to describe the characteristics of ISs later in this chapter.

'Components' is a term used widely in writings on innovation, from classical innovation literature through to ISs literature, to describe all the components that may lead to innovation outputs. In this dissertation the term has a more limited set of meanings. 'Components' refers primarily to organised institutions that lead to innovation outputs, such as universities, firms or industry, finance organizations, government and organised society. It can also be used at a lower level of generality to describe researchers, R&D labs, and so forth. 'Elements' has a more specific meaning in innovation systems literature to signal the interconnectedness of components in a system. ''Factors'' is a term used in classic innovation literature in the context of the weighting of components in specific cases.

Critical factors, for example, are derived from observation of the characteristics of innovation in international best practice cases. These have been described by Castells *et al.* (1994), Castells (2000), Etzkowitz & Leydesdorff (2000), Lundvall, Johnson, Andersen & Dalum (2002). They include both 'hard factors' and 'soft factors' as essential in innovation. Knowledge is a critical soft factor, whereas an R&D laboratory is a typical hard factor; however, knowledge is 'weighted' as more important than the infrastructure supporting it.

Critical factors in any given situation are shaped by a variety of contextual factors and have different relative significance from what they might have in other situations. As no two innovation environments are the same, the critical factors vary considerably from context to context. Nevertheless, a general account of critical factors and components that drive innovation is possible. If these aspects are not present, it is unlikely that innovation will flourish.

- General components of innovation include universities, industry and government. In any successful situation, their relationship is shaped by leadership, collaboration and focus. A common vision or focus generated by leadership in collaboration results in synergy of efforts as well as promoting further collaboration. This triple-helix system of university-industry-government in productive relationships with one another is an internationally recognised collaboration and innovation model, now generally expanded to a quadruple helix by the addition of a public or societal realm (Etzkowitz & Leydesdorff 2000; Etzkowitz & Zhou 2006).
- Research, skills, knowledge and learning capabilities, usually driven by universities, R&D labs and other research or learning centres (Edquist & Hommen, 1999; Lundvall *et al.*, 2002; Rogers, 1983).
- Capital and financing. Without the necessary funding and investment platform, the realisation of innovations and incentives for innovating is hampered (Castells *et al.* 1994).
- Appropriate infrastructure and support mechanisms, e.g. an innovation environment supported by technology and innovation infrastructure such as ICT, R&D labs, Science Parks etc. (Castells *et al.* 1994).
- Factors such as social capital, culture of entrepreneurship, trust, networking and social dynamics, sharing and openness are very important informal stimulants of innovation (Granovetter, 1973; Fukuyama, 2001; Murphy, 2002).
- Formal and informal knowledge exchange and collaboration and access to new information is vital for innovation (Lundvall *et al.* 2009).
- Incubators and knowledge and technology transfer offices play an important role in commercialization and thus form part of the innovation process (Bailey & Mouton 2005).

- Appropriate policy incentives such as tax rebates and competitions and other contributions to a dynamic environment are powerful factors (Edquist & Hommen, 1999).
- Intellectual capabilities and absorptive capacities, or the abilities of firms, and people in firms, to understand and deal with new knowledge or innovation and 'adopt' or 'absorb' innovations (Cohen & Levinthal 1990; Fagerberg *et al.* 2010).
- Development agencies and platforms and information offices, which provide an innovation intermediary role are important drivers of innovation (Harmaakorpi 2004).

The significance of these components and factors conducive to innovation at the firm level may be extended regionally, nationally and even internationally. Although it is clear that innovation is fostered through inter-connections between many different components, both these components and an understanding of how to drive or stimulate innovation are complex in practice, influenced by a wide range of factors.

The systemic approach to innovation is concerned with the whole innovation environment, or with understanding the complex interaction of the components and factors described above. The innovation environment is a complex system of interacting parts and relationships which collectively generate the functions that produce innovation.

Clearly, as a combination of different understandings and practices drawn from academic disciplines from sociology and psychology to engineering and economics (Baregheh, Rowley & Sambrook 2009), innovation studies can by no means be an exact science. However, it is unavoidable if there is to be adequate adaptation to a changing environment. Some things are clear. The most prominent feature in the literature is the role of knowledge in interactions between the components and factors that make up a system of innovation. Thus both research (fundamental and applied) and the responsive and changing role of knowledge institutions (universities, research bodies, and private sector R&D divisions) in the innovation process are vital (Etzkowitz & Leydesdorff 2000; Jensen, Johnson, Lorenz & Lundvall 2007; Rogers 1983).

Shifts in understanding knowledge or technology transfer from linear models to complex, integrated systems have gone along with shifts towards more sophisticated modes of knowledge production and research. These shifts can be seen as evidence of a changing

world's working towards a new transdisciplinary knowledge paradigm[8], with implications for both the production and application of knowledge. Among other things, it is open to knowledge from the range of disciplines but also knowledge generated outside an academic frame. This approach is particularly important in generating innovation to meet the challenges of a global and intensifying 'polycrisis' which Morin (1999) has described as a nested set of globally interactive socio-economic, ecological and cultural-institutional crises that defy reduction to a single cause (cited in Swilling 2013).

These global shifts in an increasingly sophisticated knowledge-use paradigm are thus prompted by a major intellectual need – a need to understand and respond appropriately to the complex challenges of our time. Various influences have been felt in the process. Some have attributed the shift to the appeal of governments, industry and business for university accountability (Carstens & Mouton 2002; Leydesdorff & Meyer 2006). However, cruder versions of the accountability demands have simply aggravated the 'publish or perish' syndrome and a tendency to pass the buck, undermining what is necessarily a cooperative process. In the context of innovation, accountability is always a mutual process involving the responsibility to one another of knowledge institutions, industry, the government and, increasingly, the general public. Where that mutual accountability is in place, innovation is a feature not only of developed world contexts, but also increasingly of the developing world, where universities are challenged to produce knowledge that is relevant to development (Kruss, Lorentzen & Petersen 2009). Globally, universities are looked to as boundary-spanners for knowledge development and innovation (Youtie & Shapira 2008). This gives new pertinence to Rogers' view that innovation is driven by the needs of society, and so by the response of politicians who place polycrisis problems high on the agenda for finding solutions (ie innovations) through research (Rogers 1983: 162).

From another perspective, the shifts in modes of knowledge production can be seen as evidence of universities redefining their role in a changing world. Some of this is driven by universities themselves responding to polycrisis issues. However, it is also necessarily a response to increasing instability in the perceived legitimacy of universities and their traditional forms of production of knowledge (Bailey & Mouton 2005, Kruss *et al.* 2009, Scholz & Stauffacher 2010, Scott, Gibbons, & Nowotny 2003). Furthermore, state

[8] Here the word paradigm is used in the neo-Kuhnian sense, referring to actual shifts in the communities of knowledge production and use, where current paradigms of science are not able to solve problems (Kuhn 1970).

sponsorship of research is in decline and universities are forced to innovate and shift structurally to meet the challenges of a new environment (Etzkowitz & Leydesdorff 2001; Etzkowitz & Leydesdorff 2000). Universities need to find new bases of cooperation with industry and government while preserving the integrity of the intellectual project. Among the changes in university practices are a closer collaboration with industry and government in the joint project which translates knowledge and research into 'usable' science, leading to appropriate innovations (at least for the economy, not necessarily for society). This process is intellectual in that it requires a rigorous understanding of the world and the needs being addressed.

Academia is assuming a greater role in innovation spaces through an increasing emphasis on Mode-2 knowledge production as described by Gibbons *et al.* (1994). Scott, Gibbons and Nowotny (2003: 181) write about how the nature of research processes is being transformed, placing increasing importance on: i. the steering of research priorities, ii. the commercialization of research, and iii. the accountability of science. Whereas Mode-1 knowledge can be described as research production in the boundaries of traditional science and academia for the sake of scientific advancement, Mode-2 knowledge, ''is produced in context of application, it is transdisciplinary knowledge, it is heterogeneous and organised in new and diverse ways, and it involves new forms of accountability and reflexivity as well as new forms of quality control'' (Bailey & Mouton 2005:9). The shift to Mode-2 knowledge production arises in part from the increasing pressures on knowledge producers to address the serious challenges posed by the global 'poly-crisis' and global changes, such as climate change, resource depletion, infrastructure constraints and increasing global injustices (Swilling 2010, 2013). Responding appropriately is necessarily a collaborative process, demanding changes of all involved.

From a systemic perspective there are implications as to how universities engage, act and structure themselves to produce knowledge through interacting with society as an important component in ISs. The changes in practice raise questions about the nature and purpose of higher education. Le Grange (2011) opens up the debate of 'sustainability education' as rhizomatic (networked) thinking, as opposed to arborescent (structured) or 'traditional' dissemination of knowledge. The rhizomatic concept, coupled to 'complexity thinking' (Cilliers 2007), is an interesting one, and can be strongly associated with the shift from

understanding knowledge transfer and innovation as a linear function to seeing it as an interactive and systemic process that operates within defined yet cross-cutting boundaries.

2.3.1 Diffusion of innovations

As we have seen, ISs not only involve the production or supply side of innovation, but equally involve the demand side, which has a strong influence on the diffusion of innovations in society. The supply and demand of innovation is by no means a linear process, as Kline and Rosenberg (1986) have pointed out. Linear knowledge and technology transfer models are not helpful, and the model of technology push, or supply of innovations, is not adequate (Edquist & Hommen 1999, Sharif 2006).

The diffusion of innovation is an extremely important process. Without adequate diffusion or uptake of inventions in society, new ideas, creations and inventions are by definition not innovation. Innovation needs to be commercialised or, in a wider sense, used in society. Thus diffusion of innovations concerns their uptake and the impacts they make in society. In some cases these diffusions are smooth processes, in other cases the innovations are disruptive in society. The demand or market need for innovations is created through a variety of factors that differ from situation to situation; however, it is essentially a social process. Demand may be derived from genuine needs or from 'wants' that are often associated with mass media and marketing. The pioneer of diffusion studies, Rogers (1983:5), describes diffusion as 'the process by which an innovation is communicated through certain channels over time among the members of a social system.'

For Rogers, diffusion involves the following, in all of which time is a critical factor: [9]

a) The *innovation-decision process*, which is the mental (or socio-cognitive) process of an individual who passes on information to another person (or group), who either confirms and adopts or rejects the innovation.
b) *Innovativeness*, which is the degree to which an individual is early in adopting new ideas relative to other members of a broader (social)[10] system.
c) *An innovation's rate of adoption*, which is the relative speed at which an innovation is accepted in a system.

[9] The time factor is a major element differentiating diffusion studies from social-learning studies. The latter is more concerned with 'how' learning takes place (Rogers 1998).
[10] The 'system' referred to in Rogers' work, is essentially social, but later may be extended to socio-technical as discussed in the sustainability transitions literature. (Rogers *et al*. 2009).

Rogers' work was ground-breaking in providing a model for understanding how society comes to know about, accept or reject, adopt and eventually recommend or discontinue an innovation (Rogers *et al.* 2009; Rogers 1983). In what follows, a number of diagrams illustrate Rogers' view of the processes involved in adoption and diffusion of innovation in society. The first model concerns the *innovation-decision process*. (See Appendix B1, for the model).

Although inter-personal linkages are extremely important in the diffusion of innovations, the media plays a big role in introducing the new knowledge and raising awareness of it. In today's world, because of the rapid uptake of social media practices, there is an important link between media and inter-personal linkages via social networks such as Facebook, Google and Twitter. Diffusion processes are changing all the time, because the proliferation of the internet and mobile devices has created a new form of public but personal communication (Castells 2000). However, trust remains a key element. Trust is generated when two individuals or groups and their actions meet each other's expectations (Murphy 2002). It is clear that the role of inter-personal engagement and face-to-face contact which earns trust remains an important factor in the different stages of adoption (Rogers *et al.* 2009; Rogers 1983).

Figure B1. A model of the stages in the innovation decision process (See Appendix B1, p 412) is the first version of the more famous 'rate of adoption' diagram that stems from Rogers' work, in association with Ryan and Gross (1943). They were the first to use a categorization of the differences in rates of adoption of innovations. This was a result of their findings in a study of the rate of adoption of hybrid seed corn in the state of Iowa. These were expressed graphically in an S-shaped curve that is now well known in innovation studies (Rogers *et al.* 2009). See Appendix B2, p 412 - *Figure B2: The innovation S-curve adoption ratio* (Adapted from Rogers, 1983). The curve describes a cumulative process from zero to one-hundred % of adoption. At first there is a relatively slow uptake of new innovations, after which diffusion of the innovation gains momentum and eventually flattens out after which the adoption process is complete.

An alternative model supplied by Rogers (1983) aims to show the intensity of innovativeness of social systems through the frequency of adoption and different categories or stages.

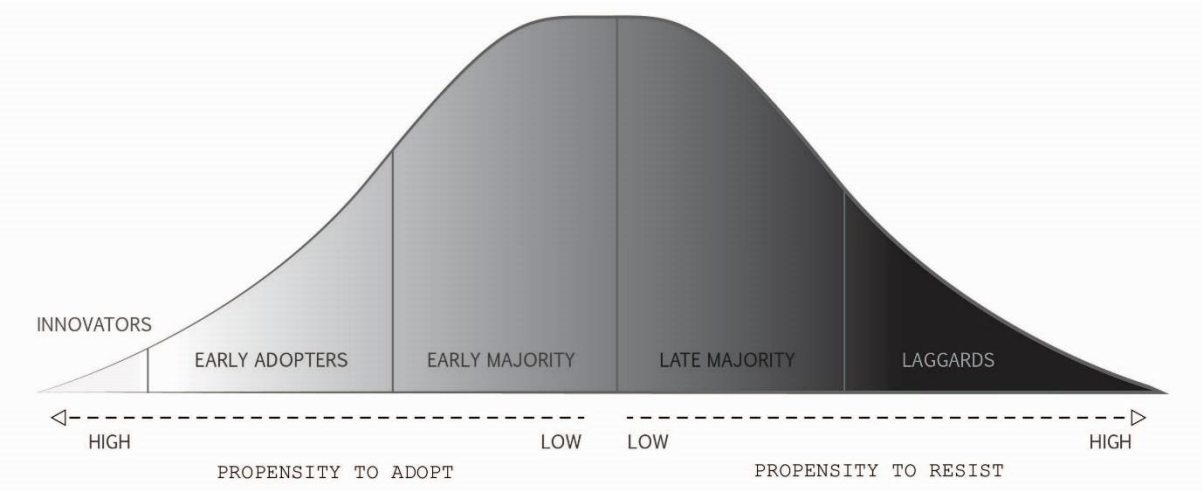

Figure 2.1: Rogers' stages of innovation adoption in society (Adapted from Rogers 1983)

What is interesting for this dissertation is the clear connection Rogers (1983) sees between social learning and diffusion theories, and how these theories differ. The link between social learning theory and diffusion theory is an important one, especially in the context of ST theory. Both innovation and diffusion are an important part of ST, as they are both essentially social processes. In this context, geographic proximity and other forms of proximity are thought to play an important role in the diffusion process. These latter points are summarised in a statement by Rogers:

> Recently, both social learning theorists and diffusion theorists have begun to move strongly towards focus on the mutual exchange of information between two or more individuals as the basis for the convergence in cognitive and behavioural change.
>
> (Rogers 1983:307)

Diffusion studies is not without its critics. A recent criticism is that its underlying theories, as understood in the broader context of global development, inequality and catch-up, reflect an 'imperialist' mind-set. Most of the theory has been developed in the global North, and attempts to recalibrate diffusion studies for the different socio-economic conditions of the global South have met with harsh criticism (Rogers *et al.*, 2009). Innovations which address problems of the global North may simply be an imposition on the global South. The concept of positive deviance (PD) goes some way towards meeting this criticism by providing an alternative. It is 'an approach to social change that enables communities to discover the wisdom they already have, and then act on it' (Sternin & Choo 2000). It is worth mentioning for two reasons. First, it stems from a paradigm shift in the understanding of innovation diffusion processes. Secondly, it is of relevance to the two case studies explored later.

Scholars such as Papa *et al.* (2006) are critical of top-down and hierarchical 'implementations of solutions' as innovations for 'problem solving' in the development context. Their criticism has opened the space for the bottom-up or community-centred approach to PD. This approach tries to build on local and indigenous knowledge as the first approach to finding solutions to problems, and as a basis for assessing the value of innovations from elsewhere. This is an increasingly important topic in development studies and also in diffusion studies, especially when talking about knowledge and technology transfer between developed and developing nations (Montalvo 2008; E.M. Rogers *et al.* 2009).

Rogers's book *Diffusion of Innovations* (1983), reveals that diffusion is essentially a social process. It has a lot to do with personal interactions and socio-cognitive institutions, such as belief systems, values and norms – summarised as 'patterns of thinking'. While the dynamics of social learning have changed in modern times and vary in different contexts and places, socio-cognitive institutions and their ability to change from one paradigm to another may be as sticky or rigid in developed places as they are in a Peruvian village, where Rogers conducted one of his studies.

It is clear from this example and from the overall discussion above, that innovation is always associated in one way or another with a need or demand in a social system. Whether the demand is derived from the existence of the innovation itself (possibly a want), or is a reflection of a felt need is a matter of debate, and can vary from innovation to innovation. However, what is clear is that diffusion of innovation understood in terms of social systems, and social learning as a phenomenon and a field of research, are both extremely important for development and economic growth.

2.3.2 Innovation for economic development

Fagerberg and Godhino (2006) point out that the question of how innovation and technology affect economic development is not only unclear, but is also contested. The idea that technology is a public good and that economic catch-up by poor nations through free-market forces happens rapidly became a popular ideal in the neo-classical school of economic thought. It was based on the assumption that technology transfer and knowledge transfer would happen rapidly on a global scale where there was opportunity to make profit. As Fagerberg *et al.* (2007) point out, this was a typical linear-thinking assumption of the balance of equilibrium through free-market forces.

Fagerberg *et al.* (2010) note that this conceptualization was hotly contested by writers such as Gerschenkron (1962) and Abramovitz (1994), who suggested that there is nothing automatic about economic catch-up–and that both institutional and organizational development are entirely necessary as a pre-condition. These debates ushered in a host of work on the institutional 'capabilities' of nations relating to their economic performance through their 'technological capabilities', 'social capabilities', 'absorptive capacities', 'adoption rates', 'learning abilities' and, lastly, also 'innovation systems'. It is important to glance at these factors.

The technological capabilities of a nation can be understood as that nation's ability to construct and apply technology in its different forms for the distribution and maintenance of goods and services in a society for the purposes of economic growth. Technological capability was defined by Kim (1997:4, cited in Fagerberg *et al.* 2010:842) as:

> …the ability to make effective use of technological knowledge in efforts to assimilate, use, adapt, and change existing technologies. It also enables one to create new technologies and to develop new products and processes.
>
> ***Social capabilities*** are defined by Abromovitz (1994; cited in Fagerberg *et al.* 2010:841)) as including the following aspects: Technical competence (level of education); Experience in the organization and management of large scale enterprises (tacit knowledge); Financial institutions and markets capable of mobilizing capital on a large scale; Honesty and trust; The stability of government and its effectiveness in defining (enforcing) rules and supporting economic growth.

Absorptive capacities and adoption rates were initially linked to the ability of nations to absorb investments and new technologies, but soon became synonymous with the ability to absorb and adopt new knowledge through learning and unlearning processes. Cohen and Levinthal (1990:128) described absorptive capacity as the 'ability to recognise the value of new information, assimilate it, and apply it to commercial ends'; and more recently Kostopoulos (2011) notes it as a prominent topic of scientific enquiry linked to economic competitiveness, innovation and the performance of a firm. The most important concern in absorptive capacity literature, related to systems thinking, is the role of knowledge inflows in a firm and how this translates into economic productivity. The focus on the firm level has increasingly expanded so that the concept of absorptive capacities and adoption rates applies also at district and regional levels (Griffith, Redding & Reenen, 2004).

Cohen and Levinthal (1990) provide a further useful perspective in summarising absorptive capacity as constituted of three processes: Search (for example, the direction of scientific

enquiry or R&D); Assimilation (or absorption) of what is found (based on prior knowledge), and Commercial application (and relevance).

Lastly, they draw attention to the 'pre-conditions' of absorptive capacity (Cohen & Levinthal 1990). In learning theory, individuals and groups having prior knowledge of a subject learn new information on a similar subject more rapidly. However, practice is more ambiguous. Precisely because individuals or groups have invested time and energy in learning a certain distinct form of knowledge code or behaviour, they will have acquired a degree of socio-cognitive preference or lock-in (rigidity). Established preferences and learning habits may thus become a barrier to the adoption of new knowledge or innovation. Cohen and Levinthal call such established preferences and learning habits in firms or organizations 'cognitive structures' (1990). These cognitive structures affect capacity to absorb innovation and possibilities for new learning. This is an interesting perspective, which becomes relevant in the analysis of the case studies, where examples of socio-cognitive lock-in and lock-out are found.

Economic progress and growth have a strong relation to knowledge and knowledge production. Knowledge assimilation by economic actors on different structural and scale levels in different contexts requires different forms and approaches to social learning. For example, learning between actors in physical proximity is different from learning on a national level. Furthermore, understanding technology and its operational field as a sub-set of knowledge is a dominant theme in much of the literature:

> The subset of knowledge that deals with how to produce and distribute goods and services, which is what interests economists most, is usually labeled 'Technology'. An open question is whether the concept of technology only refers to knowledge about physical processes, 'hardware', or if it also includes knowledge about, say, how to organise/ manage these, 'software'. For the purpose of economic analysis, the latter, broad interpretation of the term is clearly the most meaningful. Arguably, mastery of physical processes is of dubious value if one doesn't know how to embed these in a well-organised production and distribution system.
>
> (Fagerberg *et al.* 2010:893)

Innovation and economic development are affected by social or technological factors as separate domains which function inseparably in ***socio-technical systems.*** These will be discussed in more detail in the context of transition theory. Fagerberg's observation implies a view of the adoption and diffusion of technological innovation as a social process, resonating with the work of Rogers (1983).

Knowledge and learning and their relation to the development of innovation and its adoption in society is clearly a matter of major importance, at least for economic development. Yet knowledge for sustainable development should be equally important. Socio-cognitive paradigms and institutional dynamics are alluded to throughout the remainder of Part I, signalling the argument about how innovation and improved learning and perspectives on sustainability may shift techno-economic paradigms, and socio-economic systems. This shift is key to ST, and understanding it requires that the spectrum of innovation from need and research, all the way through to diffusion and use, be understood as a complex adoption system.

2.4 National innovation systems

2.4.1 Background and context

Friedrich List is considered to be the first to write about the idea of innovation systems. In his *Das nationale System der politischen Oekonomie* (1841) he described the need for a national system of learning and production to support industrial development. Opposed to Adam Smith's ideal that market exchange and allocation would provide the forces to secure the necessary factors of production, List suggested the rationality behind the organization of these factors on a national scale. This increased the role of government in development through ensuring the necessary skills, education, training and infrastructure needed for industrial development (Edquist 1997; Chris Freeman 1998).

The concept of a National Innovation System (NIS) is a recent development, first described in the work of two academics in the late 1980s. Almost simultaneously Richard Nelson (1987 and 1988) and Christopher Freeman (1987) presented theories of 'national systems of innovation' (cited in Lundvall 2010). Their approaches differ somewhat, in that Freeman writes about innovation systems from the perspective of the production and process of achieving innovation, whereas Nelson is more concerned about knowledge production and how this is related to innovation. For Freeman it is about the 'nation-specific organization of sub-systems and the interaction between sub-systems. It is about the role of research and development (R&D) in the firm, the interaction between firms and the role of government' (Lundvall 2010b). For Nelson it is more about the invention, interaction and appropriation of new technology between the private sector, public sector and universities. Nelson draws heavily on empirical case studies that lead to his theoretical work on ISs, and subsequent

explanation as to why a country is competitive–which in his view is related to the intertwining of 'science and technology' (Soete *et al.* 2009).

A third early theorist, Lundvall (1985), promotes a style of thinking towards understanding innovation systems which is distinct from those of both Nelson and Freeman. According to Soete (2009) there are three main building blocks of his theory:

a) ***The sources of innovation*** – in which he makes a distinction between R&D and learning, placing emphasis on the latter (i.e. learning by doing); he also distinguishes between corporate R&D (Search) and the R&D of tertiary research institutions (Exploration).
b) ***The nature of innovation*** – in which he suggests innovation to be a rather incremental process as opposed to something radical[11].
c) ***The role of non-market institutions in the system*** – which firstly places emphasis on the user-producer relationship, and then also the formation of institutions, defined as regularities of behaviour.

These three understandings form the basis of the theory of innovation systems, which is fast evolving into an important tool for policy development and analysis. Working together, Nelson, Freeman and Lundvall furthered work on innovation systems in the so-called Aalborg school.

The Aalborg school showed that qualitative interactions for innovation are beyond the motivation or explanation of conventional market forces of price and quantity. There is an additional focus on the concept of interactive learning rather than on transactions only. And there is an awareness that different national contexts provide different possibilities for establishing or organizing markets, and that these in turn influence processes of interactive learning, suggesting that:

> Long-term interactive learning is more easily organised in a setting where there are few linguistic and cultural constraints for the transfer of tacit knowledge and where a multi-lateral system of trust relationships can most easily be organised.
>
> (Lundvall *et al.* 2002:220)

[11] Lundvall suggests, ''it mainly consists of small steps that result from the constant learning and searching by firms. The resulting process of incremental innovations is much more of a continuum than suggested by the distinction between invention, innovation, and diffusion. An important dimension of this process is also the feedback between different actors, since each incremental innovation is at least partly a reaction to previous innovation by others who are active in the 'system'' (Soete *et al.* 2009:1165). This is something that will be discussed below in the section on system innovation and sustainability transitions, which proposes a different emphasis on innovation processes if we are to achieve sustainability.

In this understanding, there is a clear link to the importance of social processes and interactions and learning in a social system, previously emphasised in Rogers's work. In complex environments of engagement and interactive learning, various patterns become established as social institutions - understood as rules, norms, values, social preferences and cultural dimensions in society. These are conceived by B. Johnson (1988, 2010) to be fundamental in promoting and steering innovation processes.

The combination of understanding institutions and institutional economics and their role and influence on ISs was soon recognised by IS theorists. Lundvall *et al.* (2002) suggested that national institutions and institutional settings have a major bearing on the ability of economic actors to perform or produce innovations. Three institutional factors that perceivably have an effect on the national system are: i. *the time horizon of agents* - for example the manner in which long-term Japanese investment decisions and economic outlook has a bearing on production and innovation vs. the short-term Western perspective that prefers quick investments in a 'freer market'; ii. *the role of trust* - which is vital in the process of mutual learning and reciprocation; and iii. *the actual mix of rationality* - which is an important subtlety in the understanding of the behaviour of actors in ISs.

In free market capitalist systems, for example, it is expected that actors base their rationality on prices and availability of information, whereas, although in conventional markets such instrumental rationality may be the norm, in innovation processes these assumed rationalities may not be as instrumental. Innovation processes, especially in different institutional settings, depend strongly on trust, through interactive and tacit learning, so that a more communicative rationality is the predominant behaviour. Finally, it is important to note that over and above these more informal institutions, the formal institutions such as laws, clearly defined property rights, labour rights and so forth also play a role in the IS processes.

For this reason ISs must in some measure be seen as national systems, because many of these laws, regulations and policies are determined at the national or state level. The Aalborg school concerned itself with the national systems of innovation of smaller countries. Most importantly, according to Lundvall *et al.* (2002), they focused on two aspects of innovation systems: *first*, the structure of the system, i.e. what is produced in the system and what competencies are featured in the system; and *secondly*, the institutional set-up i.e. how production, learning and innovation actually take place in the system.

Whilst the national delineation of innovation systems is regarded as a 'classical' perspective, more recently there has been an exploration of different forms and aggregate levels of ISs. This is because some innovation processes demonstrably did not extend to the national level, but were contained, for example, in a region, sector or even a specific technology.

2.4.2 Institutions, interaction and learning as central to innovation systems

Lundvall (2010b) is the classical innovation writer most adamant about the link between learning, institutions and innovation, although this has also been stressed by authors such as Edquist and Hommen (1999). Lundvall makes five main points:

i) Innovation is incremental, is derived from production systems, and comes from existing knowledge. It is built upon what is already known, or what is available in terms of knowledge. Learning and interaction are key factors of innovation in his understanding: 'If innovation reflects learning, and if learning partially emanates from routine activities, innovation must be rooted in the prevailing economic structure' (Johnson 2010:34, 35).

ii) The processes of invention, innovation and diffusion are difficult to separate. It is often difficult to pin-point the exact origin or timing of an innovation. For this reason innovation is often referred to as an iterative process in the economy. In other words, information and knowledge often flow back and forth between actors before the artefact or process becomes an innovation (Lundvall 2010a).

iii) If innovation is a result of interactive learning processes in and between production processes, it is also embedded in institutional infrastructures that act as guide-posts to assert the rules of the innovation game. Institutions provide the frameworks within which interactive learning, and hence also innovation, takes place. In Lundvall's words:

> …everyday-experiences of workers, production engineers, and sales representatives influence the *agenda* determining the direction of innovative efforts, and they produce knowledge and insights, forming crucial inputs into the innovation process.
>
> (Lundvall 2010a:10).

A better understanding of how new knowledge structures and socio-cognitive institutions are derived from new demand for innovations (innovation pull), or from new technology supply (innovation push) should be seen as of paramount importance in the agenda of innovation for sustainability. Cognitive structures which will be

referred to as '*socio-cognitive institutions*' (SCIs) may be both enablers and barriers to interactive learning and thus innovation.

(iv) In Lundvall's (2009) work on user-producer interactions, he also places emphasis on the closeness between user and producer. ''User'' in this context refers to the end-user of the innovation, and producer to the producer of the innovation. The producer usually forms part of a production system or works in an industrial context. If products are relatively standardised innovations, then user-producer interactions can be relatively distant in terms of space. More complex and continuously changing innovations require a closer space between user and producer, both in terms of communication and of actual geographic proximity. This is especially true for new technological paradigms, where the need for proximity in terms of geography and culture becomes even more important, especially as:

> A new technological paradigm will imply that established norms and standards have become obsolete and that old codes of information cannot transmit the characteristics of innovative activities. In the absence of generally accepted standards and codes able to transmit information, face-to-face contact and a common cultural background might become of decisive importance for the information exchange
>
> (Lundvall 2009:17).

(v) Another very important learning element in the institutional process of innovation and production is *search* (private sector R&D) and *exploration* (public or university R&D). Search refers to learning associated with research that is linked to the production process, or is produced for commercial ends. It is usually commissioned by the private sector, and is often undertaken by the firm's R&D department. Exploration, on the other hand, is not dependent on commercial use or outcomes, and usually takes place in the university research sphere (Johnson 2010). Both aspects are extremely important for the innovation process, where search usually results in more incremental innovation, and exploration can lead to more radical or disruptive innovations.

The characteristics and more intricate elements of the NIS approach have been explained as interactive learning in relation to the production system, interacting in and between various possible institutional frameworks. The concept of *socio-cognitive institutions* is crucial in this regard. The next section summarises the discussion about NIS thus far, using elements in the definitions of innovation systems by different authors.

2.4.3 Characteristics and definitions of innovation systems

Soete, Verspagen and Weel (2009) accurately describe the concept of an innovation system, and how this system includes different components, with the state as central:

> The systems of innovation approach spells out quite explicitly the importance of the systemic interactions between the various components of inventions, research, technical change, learning, and innovation; the national systems of innovation bring to the forefront the central role of the state as coordinating agent.
>
> (Soete *et al.* 2009:1162)

Research by NIS scholars focuses on the interactive processes between the components of the system and the quality (nature) of the ties between them. For NIS theorists, the 'national' or state level is the unit of analysis. Arguably, the national plays an inseparable function in the innovation activities of any particular region or geography in a country because policies, education systems and regulatory environments are usually constant in a state. Soete *et al.* (2009) summarise the key insights or characteristics of NIS as: sources of innovation; institutions and organizations; interactive learning; interaction; social capital. Edquist & Hommen (1999:65-66) provide a more extensive list of nine characteristics of innovation systems. Edquist's list differs from Soete's in that he consciously works to an ideal form of IS, where Soete and others highlight the characteristics of previously successful innovation environments. ISs in their view can be approached from the following viewpoints: *They place innovation and learning processes at the centre of focus; they adopt a holistic and interdisciplinary perspective; they employ historical perspectives; they stress the differences between systems, rather than the optimality of systems; they emphasise interdependence and non-linearity.* (For a full explanation see endnotes).

These characteristics are not always present in all NIS, and different emphases explained here, show how the thinking about NIS, and the theory of it developed. Edquist's account of these characteristics shows the scope for further development of the concept, not only as a theory, but also a tool to be used for development.

2.4.4 Defining national innovation systems

The term NIS has come to cover both more and less formal meanings. Narrower and more formal definitions refer to a structured understanding of innovation as Science and Technology (S&T) policy, Research & Development (R&D) and knowledge and technology transfer. This lends itself to the Nelsonian focus with its interest in knowledge transfer and R&D as a means to innovation. The broader and less formal definitions of NIS include less-

tangible, but no less important, factors having a bearing on innovation, for example, trust, a culture of sharing, knowledge, reciprocation and social interaction. These less formal factors are included in all aspects of the economic structure, and the character of institutions affecting interaction and learning. The institutional frameworks which constitute ISs in general, also inform their direction of 'search', and 'exploration' but also are affected and steered by it. Emphasis on these less formal elements is characteristic of a Lundvallian view (Lundvall *et al.* 2009; Lundvall 2010a; Edquist & Hommen 1999).

The Aalborg school, and other prominent influences, including the SPRU group at Sussex and Nelson and Winter (1982) and their evolutionary theory of technology, took on both the broad and narrow definitions. A coherent view of NISs, weaving together the different views, is emerging in the work of the most prominent authors in the field. This interwoven perspective is becoming more stable, providing a theoretical base from which to analyse IS and make policy recommendations. IS, in general, as this accounts for other less aggregate forms of ISs eg regional innovation systems (RIS), are being widely used as a policy guiding tool by governments and policy makers. They are used as a means of understanding the weaknesses, failures and successes in the system (Soete *et al.* 2009; Klein Woolthuis *et al.* 2005).

NIS was a move away from the neo-classical, linear economic paradigm (Lundvall *et al.* 2002; Lundvall 2010a). The shift to systems thinking and complexity theory signalled a new approach to understanding the dynamics of innovation. This dynamic understanding has attempted to include flows of information, feedbacks, quality of ties and interactions from a systemic point of view. The shift from understanding innovation as a product of knowledge transfer to understanding it systemically is characteristic of most contemporary work on innovation systems. This can be seen in some of the most prominent definitions of NIS given below. It means that 'classical' NISs can be described as frameworks or policy tools for the organization of institutions and their arrangements, enabling them to organise their resources and arrange the diffusion of required knowledge to enhance economic growth in a region or nation state (Lundvall 2007; Lundvall 2010a; Soete *et al.* 2009).

A dedicated report by the Organization for Economic Co-operation and Development (OECD) provides this list of definitions of NIS by leading authors:

> …the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies (Freeman, 1987).

> …the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge ... and are either located in or rooted inside the borders of a nation state (Lundvall, 1992).
>
> ...a set of institutions whose interactions determine the innovative performance ... of national firms (Nelson, 1993).
>
> …the national institutions, their incentive structures and their competencies, that determine the rate and direction of technological learning (or the volume and composition of change generating activities) in a country (Patel and Pavitt, 1994).
>
> …that set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework in which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies (Metcalfe, 1995).
>
> (OECD 1997:10)

An IS can reasonably be described as a system in which related processes and interactions lead to innovation outputs, or as a system of human capabilities and resources configured to both enable the development of innovations and diffuse them in society. In this, both the formal coordination and the informal interaction are important to enable a system for producing and diffusing innovation. The conditions of interaction and learning present in such a system are significant, not only for innovation processes but for economic processes too. SD and STs are not explicitly dealt with in NIS theory, but it is reasonable to assume that conditions of interaction and learning are of similar importance for their achievement.

2.4.5 Innovation systems in different development contexts

A good example of where ISs theory has progressed towards a mission-oriented perspective, as opposed to simple economic growth, is NIS in the developing world. Here NIS may have a different institutional set-up and function compared to NIS in the developed world. There is a marked difference between the two contexts in the quality and 'thickness' of institutional frameworks supporting innovation processes (Perkins 2003).

Lundvall (*et al.* 2002) suggest that the NIS concept should be adaptable to developing countries. In making this point, they stress the importance of institutions in developing countries, because institutions are often overshadowed by 'market' forces or are taken for granted in developed countries and so become a hidden factor. For NISs in less developed countries to be successful:

> a major step [required] is to broaden and deepen the concept and to make it more dynamic. A narrow focus on the role of science and science-based activities is not what is most needed. We need a concept

> that covers all aspects of competence building in socio-economic activities. We also need to deepen the concept by getting a better understanding of processes of interactive learning.
>
> (Lundvall *et al.* 2002:216)

In the developing world context, institutions and policies supporting innovation are often weak, and are not receptive to the learning needed for success. Institutional learning and change is required in ISs for the focus of the system to shift. One such shift might be towards SD as ultimately more economically and socially rewarding than conventional economic growth. Institutional learning should be seen as one of the primary capabilities required for ISs to transform more readily. SCIs mentioned in the introduction, may play a big role in the direction and form of institutional learning. In fact, different forms of learning, as SCI change, will be required if STs are to be achieved given the global pressures of unsustainability.

NIS theorists are aware of deficiencies in the concept. The idea of an NIS originated in a developed country context, and it focused on small countries (Denmark, Norway, Sweden) with relatively homogeneous and functional institutional settings (Johnson 1988). Applying the theory to larger and less homogeneous countries such as the USA requires substantial nuancing. This challenge is considerably greater in considering developing countries. The BRICS nations, for example, are large, and often have multiple economic and innovation regions (functional or otherwise). Many are also heterogeneous societies, as in the case of South Africa, with multiple institutional frameworks and SCIs. This matter is receiving attention in an emerging literature on ISs in developing countries (Lundvall *et al.* 2009, Pietrobelli & Rabellotti, 2011; Srinivas & Sutz, 2008).

ISs in developing countries differ in several respects from those in developed countries. Some authors may even go as far as to say that developing countries don't have ISs (Lundvall *et al.* 2009). The view of this author, rather suggests is that ISs in developing countries are weak or dysfunctional as opposed to non-existent. It is assumed that if innovation activities are taking place in a region or nation there must be some form of IS. The main differences between developed and developing or less developed countries (LDCs) are the following: the science system; the focus on innovation; interaction and learning; institutions, heterogeneity and culture.[a]

These differences are important, but they vary greatly across LDCs due to external as well as internal circumstances. For example, most developing countries are not isolated from the rest of the world in terms of trade. In many instance global ISs penetrate developing countries through global value chains (GVCs) and multi-national companies (MNCs) and consortiums. These impact on and may assist in stimulating their NISs (Pietrobelli & Rabellotti 2011).

2.4.6 Innovation systems, levels of national development and the green economy

NISs are extremely important and NIS theory remains a major source of insights into ISs. These exist not only at the national level but also at higher and lower levels. As thinking on NISs has evolved to take account of manifestations of ISs from global to national, regional and local levels, it has increasingly been recognised that the context of ISs is always a strong shaping factor, affecting how they are understood and eventually their governance and policy directives. The most notable contextual differences, particularly in the roles of institutions and learning, lie between developed and developing countries.

Different contexts, in various parts of the world but also within nations, result in different specializations, delineations and comprehensions of ISs, including technological, sectoral and regional innovation systems. Each of these perspectives will be discussed in due course. In this dissertation, the RIS is regarded as more appropriate than the NIS as a perspective from which to assess and *analyse* the research problem. This is primarily because it includes a far more nuanced perspective on geographic and proximity effects in ISs. These effects form a key part of the research problem.

In the classical mainstream understanding of production and competitiveness, innovation is driven by financial gain and investment in R&D. Now, responding to a growing emphasis on achieving a global green economy (Montalvo 2008; UNEP 2011b), or, as Swilling (2013) suggests, a transition to a 6th long wave of 'green-tech' or sustainability, the richer concept of innovation for sustainability is gaining traction. ISs for sustainability or sustainability-oriented innovation systems are firmly on the agenda (Montalvo 2008; Stamm 2009). As a contribution to what is clearly an increasingly important debate, this dissertation explores how the IS concept, and more specifically the RIS concept, can profitably be modified to further the notion of SD and ST.

It is assumed that although effective, collective functioning of the elements and mechanisms of an IS creates the capacity for change. But it is the socio-cognitive perspectives of actors,

embedded in institutions that inform the direction and the speed of that change. These SCIs are influenced and influence by the spatial contexts within which they are prevalent. However, also by the social structures, such as networks extending beyond the spatial confines of any region or locality. What is at stake is how understandings crucial to our future wellbeing are able to inform innovation practice in different contexts, particularly in developing country contexts. The issues are complex, requiring a deep understanding of ISs in general and in their different forms.

2.4.7 Conclusion: Innovation system characteristics, delineations and multi-aggregations

The NIS concept has dominated innovation systems theory since it was developed in the 1980's, but alternative conceptions of ISs which emerge from and qualify the NIS concept have increasingly emerged. They focus on different aspects of ISs and how they are linked to the economic system. A good example is the development of the theory of technological systems. A group of academics in Sweden posed questions about ISs seen mainly as a mix of different technologies (Carlsson & Stankiewicz 1991). These technological systems did not necessarily conform to national boundaries, and often extended to international levels. The theory of technological innovation systems (TISs) now regards specific technologies as the main unit of analysis, transcending all arbitrary spatial and political borders (Bergek, Jacobsson, Carlsson, Lindmark & Rickne, 2008). As we have seen, the geography of innovation and the importance of region gave rise to the concept of regional information systems (RISs). A more narrowly focused interest analysed the dynamics of innovation in sectors and produced the concept of sectoral innovation systems (SISs) (Cooke *et al.* 1997; Malerba 2002). While RISs theory provides the most suitable basis for exploring the possibilities, the other forms of ISs, including SISs and TISs, have also to be brought under review.

Proponents of the RIS approach make a clear argument that not all innovation activity is functionally national, and that many processes described in ISs theory, such as learning, actually conform to or depend on regional dynamics and institutions (Doloreux 2002). In critique of the NIS concept, Cooke *et al.* (1997) argue that the concept of nation is in itself problematic and unclear, and could refer both to a nation of culturally cognate people, and to the nation state. In many cases, ISs exist at sub-national levels in regions, and have been described as collectively making up the national system of innovation (Chung 2002).

In all cases, however, the concept of innovation is not limited to new products or services in themselves. The understanding that specific innovations stem from a wider systemic contribution as a network of institutions, organizations, individuals and technologies is universal in the IS approach. ISs essentially embody social and institutional processes. Some authors, make a strong argument for institutions being the primary features of innovation systems, suggesting institutional change to be the key focus (Cooke *et al.* 1997). And ISs are interconnected, interdependent and can exist side by side, sometimes as constituents of larger ISs. Markard & Truffer (2008) point out that while ISs may differ in their system boundaries, they share similar functions. Most importantly, the processes of innovating and then diffusing an innovation in and through a system are necessarily collaborative acts. The various constituent systems are highly interdependent. For example, some technologies such as power grids don't exist independently of regional or national ISs. Most countries' power grids and technologies extend beyond a regional level, and sometimes even a national level. However, alternative power generation technology such as solar or wind power can become a localised or regionalised technology, augmenting or independent of the larger system.

Finally, this dissertation shares the perspective of Markard and Truffer (2008) on different aggregate levels of ISs, seeing them as interlinked and inter-connected, one having an effect upon the other. National systems often incorporate regional systems, and both national and regional systems include several different sectoral and technological systems in them. There is a relevant sectoral innovation and technological innovation focus in both of the case studies which we shall come to later. However, from a sustainability point of view, regional systems are the main focus. This is not only because the region can be more easily managed and monitored in relation to context, but because the RIS theoretical approach focuses on the notions of geography and proximity in more detail than the other conceptions of IS.

2.5 Regional innovation systems (RIS)

Cooke *et al.* (1997) offer an in-depth analysis of the concept of regional innovation systems. Regional can be described in many ways. For the purposes of this work, however, regional will refer to administrative districts and intra-administrative areas, such as city-regions. Both case studies take place intra-administratively, and include one specific city-region.

For authors like Cooke *et al.* (1997) part of the rationale behind questioning the relevance of the national delineation of innovation systems and favouring 'regional' delineations is that the IS concept involves extremely complex relationships which are better understood at

regional level. Another part is that the effects of innovation policies can hardly be noticed at the aggregate national level, and by the time they are, major opportunities for refinement of the policies in the light of experience have been missed. Cooke *et al.* (1997) give the example of regions in Italy that are 'quite independent' of national innovation functions, and operate even at the local level as a cluster of small and medium sized enterprises. Other examples include celebrated innovation sites like Silicon Valley in the United States of America, Emilia-Romagna in Italy and Baden-Württemberg in Germany. According to a 'strict' interpretation of the literature these represent the only true RISs (Cooke & Morgan 1998).

While it is characteristic of these regions to have strong internal, or endogenous innovation practices, their activities and networks extend beyond the national to the global level. A defining characteristic of RISs is their ability to integrate localised 'sticky' knowledge and learning with 'ubiquitous' or global knowledge and learning networks (Asheim & Isaksen 2002).

Regional systems of innovation and production have been characterised in a variety of ways. Authors such as Castells and Hall (1994) have described them as 'Technopoles', referring to the specific locational interaction between industry and academia. Morgan (1997) and Rutten and Bokoema (2007) speak about 'learning regions' as places that attract and retain knowledge, through specialised infrastructure and environments for learning, idea generation and commercialization. These typically involve university precincts, regional networks that support innovative practices, and networks of firms working in a cooperative system. 'Innovation milieu' is a similar term to describe areas of innovation with a greater focus on the cultural elements that foster innovative practices for local competitiveness (Maillat 1998; Breschi & Lissoni 2001). 'Industrial Districts' has been used to describe concentrations of industrial-type firms in particular spatial locations. They are characterised by inter-firm learning, collaboration and trust. They also do not necessarily conform to any one specific industry or cluster (Asheim 1996). 'Clusters', as the word suggests, refers to a groups of firms, co-located in a specific geographic region, usually from one industry or related industries and marked by their institutional connectedness, and shared production systems and markets (Porter 1998).

'Science and technology parks' and more recently 'innovation districts' and 'science cities' are terms which refer to important spatial components in RIS. They are usually smaller geographically than the other concepts described above. These spaces are often planned or

incentivised through co-location of industry and public research facilities, while serving both university interests and market demands. These institutionalised and 'managed' spaces may assist in the commercialization of knowledge from the university in a specific sector, or provide institutional and infrastructural support for university-industry interactions, entrepreneurship, and inter-firm interactions, collaboration and learning (Park 2011; Bellavista & Sanz 2009). The various descriptions of spatial innovation discussed above represent particularly high concentrations of innovative activity, and serve as important catalysts, component and elements in RISs as 'knowledge and innovation infrastructure'.

The array of different conceptual understandings of agglomeration economies such as science parks, innovation districts and technopoles, although different in some key respects, all share the common characteristic of being spatially located, and 'embedded' in a regional geography. This is the primary reason why the regional level is regarded by a number of authors and policy makers as the best level for understanding innovation practices, and why the RIS concept has been more frequently used in recent years (Bjørn T. Asheim & Isaksen, 2002; D'Allura, Galvagno & Li Destri, 2012; David Doloreux & Parto, 2005).

The RIS approach in this dissertation includes all the attributes, or innovation infrastructure described above, subsumed as components or 'hardware' features. Science parks, technopoles, science cities, innovation hubs and districts form part of the infrastructure of RISs. Each RIS, however, contains variations of the agglomerations, innovation, and knowledge infrastructure. The RIS concept evolved from a combination of regional science and ISs literature (Doloreux & Parto 2005). This section on RISs will be split into three main sections: explanation and definition of region for innovation systems, a guide to the RIS concept and the different focuses in the RIS literature including why the regional level is important for innovation systems research and analysis, and a systematic review of the internal mechanisms, elements and types of RIS.

2.5.1 The region as unit of analysis in innovation systems

Regions can be understood in many different ways.

> In the regional innovation approach, the term 'region' has been variously applied to territories and jurisdictions as different as the country of Denmark [Maskell 1998] the Canadian provinces of Ontario [Wolfe and Gertler, 1998] and Quebec [Latouche 1998], diverse cities [Simmie, 2001], and small-scale industrial districts below the urban level of aggregation [Asheim and Isaksen 2002]
>
> Doloreux & Parto 2004:22

The regional approach includes a diverse understanding of 'region' in terms of different conceptions of scale and attribute.

The terms 'region' and 'innovation' have been applied together to explain a variety of different agglomeration effects bound by different geographical scales. Florida (1995) and Cooke *et al.* (1997), for example, mention the increasing phenomenon of innovation taking place in distinct regions or districts in the globalizing learning economy. These spaces, although having different names, forms and functions, generally share the characteristic of being relatively concentrated nodes of activity supporting innovation. As we have seen, this activity is 'embedded' in defined geographic scales: 'learning regions'; 'innovation milieu'; 'industrial districts'; 'local production systems'; 'clusters'; 'technopoles' as well as 'science and technology parks', 'innovation districts' and 'science cities'. These innovation nodes, although sharing similar characteristics, represent different scales in the regional perspective. This requires a brief explanation of the units and scales of analysis associated with the notion of 'region' that have been used in various studies.

In some cases, 'region' refers to the *city level* as well as city-regions or metropolitan areas. Arguably urban spaces are the most influential site of innovation activity: spaces where exchange of knowledge, ideas and mutual learning readily take place. In other cases, 'region' applies to the *local or district level*, that is to areas in cities – what can be called city-regions. More frequently, 'region' is used *as a provincial unit of analysis*. The province or state as a subset of a nation then has similar policies, platforms, leadership organizations and guiding institutions that have an effect on innovation in the region (Doloreux & Parto, 2004).

In this dissertation 'regional innovation system' refers to all innovation activities, supporting infrastructures, institutions and organizational forms that enable or diffuse innovation in a functional area, including a province, a city-region or metropolitan region. Regional may thus span political boundaries or local administrative districts because it refers to a functional economic or innovation area. Sub-units of analysis, such as city-region, may then be included as components of a RIS. They may also be referred to as local innovation systems (LISs) embedded in a RIS. In this dissertation LISs are seen as part of RISs, so only RISs are referred to in the discussion which follows.

2.5.2 Orienting RIS, and its focuses in the literature

Doloreux (2002) attempts to establish a more solid conceptual and theoretical base for RISs. He tries to answer four questions:

i. From which of the theoretical perspectives does the RIS originate?
ii. To what extent is a RIS different from other new forms of territorial systems?
iii. Can different forms of RIS exist? and
iv. What does the RIS concept fail to address?

These questions can be used as guidelines of enquiry for the remainder of this section. They will be answered indirectly in the review of the literature below, and directly in the conclusion of this sub-section.

The theoretical development of the RIS concept is recent, with the topic attracting considerable attention in the 2000s as more researchers have come to recognise the importance of the region for innovation (Asheim *et al.* 2011). In an overview of RIS literature, using 'author co-citation analysis'[12] to show clusters of the most cited authors, D'Allura *et al.* (2012) distinguish between five kinds of RIS, each with a different emphasis. Using their methodology and applying this to a search of peer-reviewed journals with an impact factor in the fields of business, management, economics and geography they found twenty-four core literatures.

These findings are interesting for showing a distinction in the emphasis and focus of RISs. Figure 2.4 shows four different quadrants. Micro refers to a largely individual unit of analysis, and macro to an aggregate or social unit of analysis.

2. Micro: *Regional Innovative Capacity (C)*	**1. Macro:** *Regional Innovative Capacity (A;B)*
3. Micro: *Firm Innovative Capacity (C; D)*	**4. Macro:** *Firm Innovative Capacity (A;E)*

Figure 2.2 Differentiated RIS literatures (Adapted and redrawn from D'Allura et al. 2012)

The general findings of the review and classification of the RIS literature suggest, first of all, that each of the clusters is quite distinct, and secondly, that there is a gap in the research of

12 In co-citation analysis the data compiled are counts of the number of times two documents are jointly cited in later publications. The analysis is based on the premise that authors cite papers they consider to be important to the development of their research. As a result, heavily cited articles are likely to have exerted a greater influence on the subject than those less frequently cited. For an overview see D'Allura *et al.* 2012:142.

firm level interactions with the regional innovation system at a more social level (D'Allura *et al.*, 2012). In addition,

> The factor analysis shows that although RIS studies is intended as an independent area of research, its intellectual roots are wide spread, rendering it an interdisciplinary field of research in which insights are drawn from social, economic, cultural and political sciences. The factors identified show the presence both of approaches which, to different extents and in diverse ways, underscore the role of social structure, institutions and contextualization in 'real places' – regional science, social perspective and international management – and those which are more abstract and formal, or less 'social' – knowledge based view and organizational learning, economics of innovation approaches, and the evolutionary approach.
>
> (D'Allura *et al.* 2012:150).

These classifications of the literature are useful in beginning to characterise and define what RISs are, and for setting the scene for a deeper analysis. Briefly outlining this, distinction is made, for example, between extra-regional group C network perspectives, which don't place as much emphasis on the spatial dimension, and those of group B, which recognises the specificity of place and its role in the innovation system.

RIS is a complex concept, involving various approaches, focus areas and viewpoints. In this dissertation, no preference is given to any specific view of RIS. Rather, the distinctions allow for multiple or 'thick descriptions' in the reflective analysis between the literature and the cases. What is meant by thick descriptions is that multiple theoretical vantage points in the description can be alluded to. Each perspective and 'take' on RIS, therefore, has a complementary relation to the others, and should be recognised as such. Below, the complexity of the RIS approach is systematically unpacked.

2.5.3 Defining the elements, mechanisms and key characteristics of RIS

A final in-depth review centres on defining the key characteristics of RISs as elements and mechanisms of a system. These elements and mechanisms of innovation are understood in the regional context to have an effect on the dynamics and functioning of RISs. The recognition that innovation processes often 'play out' at the regional or 'micro' level has been noted even by the NIS theorists:

> The central idea in modern innovation systems theory is the notion that what appears as innovation at the aggregate level is in fact the result of an interactive process that involves many actors at the micro level, and that next to market forces many of these interactions are governed by nonmarket institutions
>
> (Soete *et al.* 2009:1163)

This 'micro' level could also be interpreted as the 'local' level, which means that these social activities of interactive learning and knowledge transfer take place (although not exclusively) in relatively close proximity (geographic or otherwise) [13]. Innovation and related economic activities are often not evenly spread across the geography of nations. In many cases they are specific to certain regions or districts and specialised as certain industry sectors or production systems. The RIS perspective, in comparison to the NIS perspective, places a greater emphasis on spatial characteristics, as well as on micro-level interactions in regions. A particular emphasis is on firm-level interactions and interactive learning, and the dynamics of these interactions in the context of different forms of proximity.

Doloreux (2002) makes three important points about RISs: i. RISs are essentially social systems (which conform to the NIS perspective, and Rogers' work), ii. they involve interactions between different sets of actors, especially between the public and private sector, in a systemic way, and iii. they express systemic patterns of interaction that increase and enhance the localised learning capabilities of a region. Doloreux makes further distinctions between four basic elements, *firms, institutions, knowledge infrastructure* and *policy-oriented regional innovation*, and between internal mechanisms of RIS including *interactive learning, knowledge production, proximity, and embeddedness*. These will serve as basic guidelines for interpretation of RIS in what follows. To them will be added information from the perspectives of several other authors, to best determine what the elements and mechanisms of RIS are that are important for our purposes.

Recognising the elements and mechanisms of RISs is important, as they refer to the inner working and functioning of ISs at the regional level, revealing the general characteristic of a RIS as a spatially based 'localised social system of innovation'. The finer details of these inner workings of RIS, expressed as an interacting system of elements and mechanisms, are of crucial importance in the analysis of the case studies. An understanding of the intricacies of RISs is important for comprehension of subtleties in the system, and so for being able to influence the direction of innovation. Socio-cognitive institutions (SCIs) are one such subtlety, of particular importance for the remaining arguments, and measureable not quantitatively, but qualitatively.

[13] Geographic proximity is but one form of proximity. This is expanded on below, and forms an important part of the theoretical foundation of this thesis.

Reviewing the literature confirms that this account of RISs as elements and mechanisms will be useful in the analysis of the case studies. However, these are not necessarily sufficient and require the inclusion of a few additional descriptive elements, such as *financing*, and mechanisms as 'linkages' or flows of knowledge and information. Cooke *et al.* (1997) describe an RIS as a more extensive list of combinations of elements:

> University research, research institutes, technology-transfer agencies, consultants, skills-development organizations, public and private funding organisations and, of course, firms, large and small, plus non-firm organizations involved in innovation are the main elements.

However, many of these elements could be brought together under one head, such as knowledge and innovation infrastructures, or firms. Cooke describes linkages more succinctly as a set of flows:

> Linkages can be specified in terms of flows of knowledge and information, flows of investment funding, flows of authority and even more informal arrangements such as networks, clubs, fora and partnerships.
>
> (Cooke *et al.* 1997:478)

These connections of knowledge and information between the elements of an RIS are crucial to its effective functioning. Although recognised as important, the idea of flows can be 'subsumed' under the notion of the connectedness of the elements. Proximities and embeddedness are terms related to the nature and quality of connections. Finally the idea of connections will also be dealt with in a subsequent section on assessment of the strengths and weaknesses of RIS, and their different ideal types. The notion of flows and connections between the elements in RIS is a cross cutting theme.

Whether labelled as components of an NIS or elements of a RIS, in most cases they are synonymous. Similarly, the idea of mechanisms of IS has been described in several ways. For the remainder of this dissertation, it will be useful to integrate these perspectives into two coherent features of RISs, namely elements and mechanisms (both internal and external). Understanding an RIS as a set of connections between these elements and mechanisms will be useful in describing its core features.

2.5.4 The elements of a RIS

The elements of an RIS are: firms, institutions, knowledge, innovation and technology infrastructure and policy. Under each of these categories there are sub-elements which are no less important.

2.5.4.1 Firms

The role of firms in a RIS is described on a more micro-level than in IS literature, covering a range of interaction, from interaction between individuals (in and between firms), to firm-level organizational interactions. These interactions take place both formally and informally with the purpose of exchanging knowledge and information in an interactive learning process. This process is described in RISs literature as central to innovation (Doloreux 2002; Lundvall 2009).

Firms play a central role in the RIS, both as interacting organizations and as learning organizations. This is evident in the empirical work done by Asheim & Isaksen (2002) and Coenen *et al.* (2004). They have researched the dynamics of clusters and their interaction with local or international knowledge organizations. Each firm has its own ability to obtain, retain, reorganise and distribute knowledge through organizational learning. This happens through a process of interactive learning between agents internal to the firm as well as between internal and external agents, through both 'search' (i.e. internal R&D) and 'exploration' (i.e. through collaboration with a university) (Asheim & Isaksen 2002; Dosi 1988). Without such a flow of knowledge a firm is not equipped to learn and eventually innovate.

Firms playing a central role in RISs tend to congregate around sources of knowledge. The patterns of firm agglomeration depend on their needs: of either tacit or 'sticky' knowledge (more firm-to-firm or inter-personal collaboration), or 'ubiquitous' or 'codified' knowledge often exchanged by R&D labs and universities[14]. Accordingly, the agglomeration effects, or the spatial character and geographical proximity of clustering in a region is quite often dependent on the form of knowledge required by firms. This usually varies between sectors or related industries as clusters (Asheim & Isaksen 2002; Coenen *et al.* 2004; Moodysson, Coenen, & Asheim 2008).

2.5.4.2 Institutions

Institutions are defined variously by different authors. North (1990) sees them as guides for human interactions, similar to what Lundvall (2010a) refers to as 'guideposts' for stability and change in society. Setterfield (1993) refers to institutions in a more economic context as 'social relations' that frame the activities of production, consumption and exchange. Potts

[14] These concepts will be explained further below.

(2007) argues from a more 'institutional economics' perspective that institutions and their definitions are so varied, that it is difficult to pinpoint exactly what they are. He also suggests that institutions are invariably present only at the meso-level as opposed to the micro-level in a socio-economic framework (See Dopfer & Potts (2009) for more details on the micro-meso-macro institutional economic framework).

The danger of too broad a definition of institutions will be overcome here by referring to them specifically in the context of ISs. Institutions are the social 'rules' of inter-actions between territorial, administrative and scalar elements in the dynamics of a 'region'. Influences in shaping them include socio-political and socio-economic factors and the cultures and values as institutions in the RIS. In some cases these may be territorially and culturally specific and in other cases not. Invariably, a mix of factors and forces shapes institutions in an RIS, having an influence on the rate and bearing of innovative activity in a region. Understanding the dynamics of 'regional' elements and how they constitute and shape institutions in the RIS in a defined geography is important.

The notion[15] of level will be dealt with briefly here, and expanded on in the section on macro-, meso-, micro- and multi-levels in part II. The claim that institutions exist primarily at the *meso*-level is worth noting, as it provides an interesting link to the concept of *regimes* in ST literature. Potts (2007) suggests that in the framework of neo-institutional economics, institutions can be defined as a stable *rule population* as the outcome of a *meso trajectory* which includes the following segmented definitions of institutions:

a) Institutions are artificial in being human artefacts, but also natural in being widely self-organizing and emergent.
b) Institutions are individual in that they relate to human action, but also social in that they are transactions that produce coordination between a system of agents.
c) Institutions are structures that coordinate a system of agents, but also processes that exist in historical time, subject to evolution and entropy.
d) Institutions comprise the economy as markets, organizations and correlated behaviours, but also constitute the economy as the legal/social/political/cultural ''rules of the game' that define the space of economic opportunity (Potts 2007:342).

[15] The basic concept of meso, in this context refers to a socio-economic level of aggregation, the level between the macro and micro. For more details see (Potts 2007), and Part II, where the discussion about multiple levels is taken further.

One of the first scholars to talk about institutions in the context of RISs was Cooke (Cooke *et al.* 1997). He saw 'institutional change' as a fundamental part of the innovation process and the regional context as having an important bearing on institutions. This was because regions often have a shared culture, territory or devolved administrative and/or political organization that supports important dimensions of institutions. This was the start of a recognition that institutional frameworks (as discussed in the NIS above) conform not only at the national level, but also clearly manifest with an effect on innovation processes at the regional level. A variety of factors may be responsible for this, including more localised or regionalised cultures, norms and values; differences in languages; differences in political ideology; differences in business culture; and, more formally, differences in regional policy, laws and regulations, especially in the case of federal sub-national units of government, including local government. This is suggested by Cooke *et al.* (1997:480):

> Clearly, regions have evolved along different trajectories through combinations of political, cultural and economic forces. We may define all such regions as territories smaller than their state possessing significant supra-local governance capacity and cohesiveness differentiating them from their state and other regions.

RISs literature has a greater focus than NIS on multiple levels of institutions, and a better comprehension of their complexity at multiple levels of inter-relation and varying scales of governance and systems (Coenen *et al.* 2004, Asheim & Coenen 2005, Cooke *et al.* 1997). This is reinforced by Doloreux & Parto (2004: 25):

> Institutions are context-specific and collectively act as an integrated web running through different systems (e.g., social, economic), scales of governance (e.g., local, regional, national), and levels of inter-relation (e.g., among individuals, organizations, societies).

A multi-level approach can be used to understand the structural contexts or strengths of institutions as levels. The influence of the state on these institutions on the national level cannot be ignored, e.g. the legal frameworks, national policies or incentive structures of formal institutions. Consequently, there remains a degree of difference in interpretation of institutions generally. Five differing interpretations have been described by Doloreux & Parto (2004) as types of institutions (see End Notes). They summarise their own work by stating:

> …when we speak of something as being 'instituted' we at once allude to something that has been 'learned' and adopted by individuals, singly or in groups, which affects inter-relations at all levels; something by which individuals or groups of individuals may be characterized at different scales; and perhaps most importantly, something that reveals a degree of relative permanency as manifested in habits, customs, and so forth in or across systems. (Doloreux and Parto 2004:26)

2.5.4.3 Knowledge, innovation and technology Infrastructure (KITI)

Knowledge, innovation and technology infrastructure (KITI), in the context of RIS, refers to both 'soft' and 'hard' infrastructures, or architectures. Soft architectures may refer to a wide range of social and institutional aspects, from interactions and mutual support mechanisms for firms to multi-organizational levels, to institutional levels in various territories.

The narrower description, or hard architectures, refers to tangible infrastructures that are prevalent in different forms in a RIS, or NIS for that matter (Balzat & Hanusch 2003). Tödtling and Trippl (2005) make a broad distinction between structures that support 'exploitation of knowledge' and those that 'generate and diffuse knowledge' as sub-systems of RIS. It is possible to make the following further distinctions:

a) ***Spatial-innovation support structures:*** science and technology parks and science cities supported by public and private sector interests. Spatial concentration results in an infrastructure that specialises in knowledge exchange, learning, innovation and commercialisation as spatial nodes or districts in RIS (Cooke 2001).

b) ***Knowledge and innovation exchange structures:*** platforms, organizations and agencies that transfer knowledge and information from and between universities, firms and society and assist in knowledge exchange between the various role-players or innovation actors in a RIS. (Saublens *et al.* 2008; Youtie & Shapira 2008).

c) ***Research and development (R&D) structures*** form an intricate part of the knowledge and innovation infrastructure of RISs in universities, national laboratories and other tertiary research institutions. (D. Doloreux 2002; Saublens *et al.* 2008).

2.5.4.4 Policy

Policy is a major factor in the stimulation and support for innovation at both the national and regional level. However, there is explicit recognition by countries, notably in the EU (Saublens *et al.* 2008), that governance and enhancement of innovation at the regional levels is most appropriate (P Cooke, Boekholt, & Todtling 2000). The primary reason is to focus on improving the capabilities and competitiveness of firms in the regional context by continuously improving their functional environment. The regional level is regarded as the most responsive level for policy learning and implementation. One should be cautious, however, about any 'one-size-fits-all' policy approach, which sometimes stems from a 'copy-and-paste' of successful regions. This is made clear by Tödtling and Trippl (2005), who point out that each region has a unique blend of innovation activity and thus requires responsive

policy design. However, policies for innovation do not always reside at the regional level. National policy has, in fact, been quite successfully implemented by national authorities, who can also implement in a regional context. An example of the latter is the Technopolis programme in Finland. The national level of policy and implementation at a regional scale has, however, also seen relatively unimpressive results – for example the UK's regionalised science centres – which were organised by national government (Philip Cooke & Morgan 1998). Despite some examples of success at the national level, however, the region remains a favourable level to draft and implement innovation policies. The core purpose is to promote a more responsive and adaptive policy approach, so as to enhance the general support environment for learning and innovation for firms and organizations. Regionally-oriented innovation policies thus have the ability to provide an institutional framework to enhance the economic competitiveness of the region. This may include:

> Managing the science base; providing financial incentives for innovation efforts, technology-diffusion policies, and initiatives; promoting programs and new technology-based firms; and creating and maintaining intangible assets that favor innovation and the transfer of technology.
>
> (Doloreux 2002:248)

2.5.4.5 The Region

'Region' has a range of meanings in the RIS context, including those embodied in the terms regionalization, regionalism and micro-constitutions. The first two terms were first used by Cooke *et al.* (1997) in the context of ISs. They touch on important insights into the relationship between a spatial territory which is usually associated with a region and the formation of institutions specific to that territory making it a region. However, sometimes regions extend beyond the spatial boundaries of a territory. For instance, the first term refers to a supra-local territory, as in a province or constituent state of a country – but the economic region may extend beyond these borders (connected in various ways). Thus a region can also be limited by its political definition: by having a territorial boundary, it is defined by its political borders. It may or may not have a shared cultural history and identity. It is predominantly an administrative territory. Regionalism on the other hand refers to a territory which has a collective and strong cultural identity. This may be based on a political preference within a nation state, without necessarily conforming to administrative boundaries. The preferences that are contained in this kind of region may lead to a new cultural institution, or a new institutional ordering. Good examples include the Basque and Catalan

regions in Spain (Cooke *et al.*, 1997), which have regional innovation systems distinct from the rest of Spain, related to their culturally and regionally-bound institutions.

This kind of cultural territory shapes its own independent cultural institutions. These often stem from distinct ways of thinking that eventually have an effect on the 'design thinking' of innovations coming from that region. What is important to notice here, is that the shaping of new institutions, as new norms, habits, trust and patterns of interaction, is often also territorially or spatially bound and can be likened to a new and distinct form of 'social capital' of that region (Coenen *et al.* 2004). Additionally a distinct, 'negotiated, evolving, collective social order' (Scott 1997 cited in Cooke *et al.* 1997) becomes characteristic of that specific region or territory. The inherent nature of that 'social order' is determined by a more complex institutionalised social process called 'microconstitutional regulation'. It:

> …establishes, to some extent organisationally, the institutional routines, norms and values by which actors may come to trust each other collectively. North 1993 distinguishes 'conventions' which are tacit, from 'rules of the game' which are more codified elements of such microconstitutions. Different institutional settings will be likely to give rise to distinctive conventions or forms of collective social order leading to the establishment or enhancement of different kinds of organisations and even, to some extent, rules of the game or microconstitutional regulation. Put together, this 'social capital' determines the posture and direction of practical action and hence the evolutionary processes of the region.
>
> (Cooke *et al.* 1997:480).

This insight into how regions and territories have an important co-determining effect in shaping institutions, either internally through regionalism and micro-constitutions, or externally through regionalization is worth noting here. This dissertation will explore the general link between (territorial) region and institutional variety through the term 'socio-spatial'; and will more specifically investigate the forces that shape socio-cognitive institutions within geographic scales in RISs as multi-level forces extending beyond the geographic boundaries. These will be explored and framed through the theoretical lens of proximities, an explanation of which comes below. Region- and place-specific SCIs are an important detail in the sustainability transitions debate.

2.5.5 The internal and external mechanisms of a RIS

The mechanisms of a RIS as interactions and processes between the elements are discussed here. These are: interactive learning between actors and organizations; embeddedness of RIS components, social networks and institutions in a regional context; knowledge production by universities, R&D labs, the private sector and how this knowledge is transferred in a regional context; and financing, which has a major ability to stimulate or stifle innovation in a region

depending on its control. These mechanisms shape and are shaped by institutions in geographic or spatial contexts. Their ability to do so is closely related to proximities and their different forms, an aspect of central importance in the dynamics and shaping of institutions in a regional context. Proximity refers not only to geographic proximity, but also to social, organizational, institutional and cognitive proximities. A more general distinction can be made between 'absolute proximity' (geographic distance) and 'relative proximity' (as social or functional connectedness). It is known that geographic proximity has an effect not only on the other forms of proximity, but also on the mechanisms of a RIS, providing a solid base from which to begin to answer the secondary research question: about the effects of scale, geography and proximity on SCIs. The closeness or distance between agents, organizations and institutions has a particular significance in the functioning of RIS mechanisms. SCIs exist in and are shaped by the mechanisms of a RIS, and more subtly by the effects of proximity.

2.5.5.1 Interactive learning

Interactive learning (in proximity) is a mechanism vital to all levels, forms and delineations of innovation. Without learning, which happens through interactions between people, firms and organizations, and public institutions, there would be no innovation at all. This is because novelty in society often comes about through the sharing of new ideas, methods and processes that alter the status of social structures. Learning may take place individually, but interactive learning, as the term suggests, involves interactions between the elements or components of the RIS. At a micro-level this involves learning between actors, which may be advanced by a 'culture of learning' through organizational support and institutional frameworks stimulating learning for innovation (Doloreux, 2002).

Depending on the form of knowledge, learning does not usually take place in isolation and requires interaction. This is especially true for 'tacit' knowledge, or knowledge that cannot simply be transferred from one agent or organization to another, but is generated by experience, through 'rubbing of shoulders' interactions between individuals, firms and organizations. These are usually specific to a cluster or industry within a particular space (Asheim & Coenen, 2005; Asheim & Isaksen, 2002). Malmberg and Maskell (2006:4) point out that 'the processes of localised learning are closely related to the benefits of spatial proximity between interacting parties' and 'many types of learning continue to benefit from regular and direct face-to-face contact, while other learning effects are associated with communal sharing of cognitive repertoires'.

Knowledge that can be transferred without face-to-face interaction is 'codified' or 'ubiquitous' knowledge (Asheim & Isaksen, 2002). Codified knowledge, as the term suggests, conforms to terminology that can be interpreted and understood universally - making this kind of knowledge ubiquitous. The general rule is, the more tacit the knowledge, the greater the dependence on spatial proximity and trust (Malmberg & Maskell 1997). Alternatively, the more ubiquitous the knowledge, the less spatial proximity is relevant, as it can be transferred without direct contact (Malmberg & Maskell 2006). A distinction can then be made between local or 'sticky' knowledge and global or ubiquitous knowledge (Asheim & Isaksen 2002). In the case of sticky knowledge, interaction between elements (or components) in the innovation system takes place through connections and networks between actors in the system. Hence proximity between these actors is of particular relevance. There are two categories of proximity: 'absolute proximity' (geographic distance) and 'relative proximity' (as connectedness). These will be discussed in detail in the next sub-section.

Firms often learn through a willingness to interact with other firms and organizations, because they recognise that useful knowledge exists outside the firm. But firms also have limited resources and are not always able to process knowledge internally, so learning also depends on the capacity of a firm to learn, especially when the kind of knowledge requires training, expertise or 'tacit' know-how. This kind of knowledge cannot simply be transferred from one organization or firm to another – it requires interaction and learning (Cooke *et al.* 1997). Several authors (Asheim & Gertler 2006; Asheim & Isaksen 2002; Asheim 1996; Coenen *et al.* 2004) have said that learning of this kind happens more easily when the distance between agents is closer. Localised learning describes how interaction at the local level results in distinctive cognitive repertoires (Malmberg & Maskell 2006). Relatively tight clusters in similar or related industries benefit significantly due to their geographical proximity (Malmberg & Maskell 1997). However, each case is different, and this usually depends on the nature of the industry (Asheim & Isaksen 2002). It is argued that a shorter geographic distance reduces the transaction costs of interactions, and benefits the firms in a cluster. It makes it possible for them to create, acquire, accumulate and utilise knowledge at a faster rate due to being located in close proximity (Malmberg & Maskell 1997).

However, proximity is not always a benefit. Sometimes, highly competitive firms with easily transferable knowledge suffer from unintended knowledge spill-overs, in extreme cases finding themselves needing to relocate. It is generally understood however, that highly competitive firms in the same industry will not collocate in the first place (Cantwell &

Santangelo 2002). The main point to be made here, is that agglomerations and clusters are often present in regional contexts because of the ability to learn from each other as firms, and in partnerships with research organizations like universities (Asheim & Coenen 2005; Coenen *et al.* 2004). A region's innovative capacity may be related to its ability to learn and foster interactions between the elements of a RIS.

Finally, learning may take place in three dimensions: vertical, horizontal and spatial (Doloreux 2002; Malmberg & Maskell 1997). All three dimensions are related to time and geography 'and the fact that spatial proximity makes face-to-face contact easier (less time consuming, less tiresome) and tends to carry with it an element of social, cultural and, not least, cognitive proximity' (Malmberg & Maskell 2006:5).

Vertical learning networks conform to vertically integrated production systems between firms. For example the output of one firm may be the input of another. It is therefore vital that these firms communicate to improve their internal processes. Interactive learning in the vertical dimension often leads to innovations through firms and their customers. Eventually, innovation may take place in response to the signals they give each other. These vertical linkages 'possess knowledge, experience or skills useful for undertaking dissimilar but complementary activities' (Malmberg & Maskell 2006:5). University-industry relations also come into play in the vertical dimension, especially when firms are collocated and in close proximity to a university precinct. The resulting knowledge spill-overs and learning by firms through both formal and informal networking and collaboration with universities occur most beneficially in close proximity (Malmberg & Power 2005). Informal networking, an additional 'social' dimension, takes place in closer spatial proximity. Generally, vertical learning takes place between firms that are linked through value chains, forming part of a wider production system (i.e. firms that cooperate rather than being in competition). Horizontal learning and networks, by contrast, are characteristic of firms in a similar industry or cluster (i.e. they do compete) (Maskell 2001). These are important insights, in the regional context, because these kinds of interactions in firms, between firms, and between firms and universities are often overlooked. That may suggest why, in some regions, there is less interaction and sharing of knowledge than in others. These kinds of interaction also have an effect on the shaping, 'tacitness' and transferability of the SCIs of a region or place; SCIs which have a clear link to knowledge and the perceived value of specific knowledge in the regional dynamics of innovation.

Horizontal networks can be categorised into two types, *knowledge networks* and *trade networks*. Whereas trade networks concern the relationships between users and producers, knowledge networks are more to do with innovation and new sources of knowledge in the cluster and between firms. Trade networks are important, because they allow firms to share information about the needs of consumers, clients and customers and consequently improve their own products or services through innovation. Through such sharing a firm often learns where problems lie and that often results in innovation. Knowledge networks generate new knowledge and new perspectives on knowledge and its possible significance. Turning new knowledge into innovation is advanced by interaction and learning between firms, and by collaboration between firms and various knowledge institutions. Both of these kinds of networks are important and characterise an RIS (Doloreux 2002).

The third dimension in which learning can take place is spatial. Geographic proximity plays a role in interactive learning in different ways. As mentioned, the knowledge spill-over effect is not always positive and, in terms of vertical networks, has not been shown conclusively to have any particular benefit. Whether intentionally or not, firms learn from each other when they are located in close proximity in the horizontal dimension.

Firms in a cluster or in close proximity may benefit from at least three aspects: *i. Observability*: the ability of one firm to see and know what others are doing, because of close proximity; *ii. Comparability*: the ability of firms in close proximity to know when another firm has made the right choices. When firms in the same industry are situated in the same environment, faced with the same choices, their ability to compare performance is simpler, so 'firms with similar capabilities in the horizontal dimension constantly imitate the proven or foreseeable success of one another' (Malmberg & Maskell 2006:7). *iii. Neighbourhood effect:* the implications of the social dimensions of spatial proximity. The wider social environment of firms, including interactions and dealings with society in general, constitutes the neighbourhood. Retired professionals, public servants or skilled persons without the need for personal gain, who often share useful information, are a good example of contributors to the 'local buzz' or 'coffee culture' which is an important part of interactive learning. It stimulates new ideas and thinking, and it provides leads or cues that aid in the process of interactive learning opportunities and innovation. 'Buzz thus refers to the information and communication ecology created by numerous face-to-face contacts as people and firms in the same industry collocate in the same city, district or region'

(Malmberg & Maskell 2006:7). The importance of this kind of interactive learning should not be underestimated. Trust is a precondition for it, and there is usually a higher degree of trust between actors who share a specific geographic space, such as a town, technology park, district, or city precinct. Malmberg and Maskell (2006:7) sum up the benefits of the neighbourhood effect:

> …spatial proximity stimulates firms to develop similar language, technology attitudes, and interpretative schemes [Lawson and Lorenz 1999; Maskell and Lorenzen 2004] … Local milieus, thus, consist of agents that are bound together by day-to-day interaction, based on the same expertise, a common set of technological knowledge, and similar experience with a particular set of problem- solving techniques.

The effect of proximity on developing similar languages and interpretative schemes is of particular relevance and importance. It is relevant to the development, formation and lock-in of SCIs. SCIs are a kind of 'institutional language' or sets of social paradigms aligned to particular societies or communities. Evidence suggests that spatial proximity has an effect on social learning, through face-to-face interactions which build trust and a common language. Similarly, this neighbourhood effect is perceived to affect the shaping of the SCIs of various communities. In other words, specific socio-cognitive communities may be entrenched (locked-in) because of the neighbourhood effect. Alternatively, the neighbourhood effect may stimulate new socio-cognitive institution building through interactive learning in a specific region, geography or district. These new socio-cognitive institutions may accept or reject new technologies, changing the structure or direction of the RIS. It is also reasonable to suggest that, due to the proximity effect, these new socio-cognitive institutions may spread throughout the localised RIS more readily than on wider scales. Thus, novel socio-cognitive institutions in these 'neighbourhoods' of RIS may likely be developed due to social and geographic proximity. This has far-reaching implications for the dynamics of sustainability transitions, when understood from this socio-cognitive perspective. This is explained more fully below.

Local social interaction in close proximity – a feature of the 'neighbourhood effect' – has influence on innovative performance. This takes place by means of 'conversion through conversation' and 'observer effects' stimulating the innovation and diffusion of technologies in society. Local social interaction has been shown to transfer knowledge about the latest opportunities or trends. In many cases this happens through *environmental observation* (seeing and hearing about new ideas and acting upon them for the greater good of the

community), or *emulation* (which is about copying social behaviour and practices without necessarily interacting face-to-face) (Malmberg & Maskell 2006).

2.5.5.2 Proximities

Whilst spatial or geographic proximity has been described quite extensively in the c, and its relevance to local buzz, has been discussed. The latter is vital in another way. Whereas local buzz may provide the capacity to enhance and direct the knowledge search function, 'global pipelines' provide the channels for flows of external information and knowledge to a RIS.

In his frequently cited critical assessment of proximity, Boschma (2005) identifies five different ideal types of proximities. This does not mean that he neglects the importance and influence of spatial proximity on the other forms of proximity. Rather, he provides this critique as a way of explaining that spatial proximity is a necessary but not a sufficient factor to understand interactive learning processes in RISs. He also shows that proximity in all its forms is not always a good thing, as too much proximity can result in 'lock-in', which can act as a hindrance in the learning and innovation process. Boschma's five proximities are:

a) ***Cognitive proximity*** – As the name suggests, this kind of proximity has to do with 'the kind of cognition' or the 'substance of the knowledge base' of actors and organizations[16]. Cognitive proximity includes the extent to which groups and organizations share knowledge bases with one another in the same industry. This also depends on whether the innovation is taking place organizationally or technically. It is clear that there needs to be at least some form of cognitive proximity for the efficient transfer of knowledge and information. Without some overlap in understanding as a shared knowledge base, learning would either be impossible or extremely slow. There needs to be a minimum level of cognitive proximity between them for a firm to be able to process information or adopt a new technology from another source. Below that level, it becomes too costly for the firm. On the other hand, too much cognitive proximity in or between organizations in a system may result in 'lock-in', so that new information or knowledge bases from outside the system are experienced as too foreign to absorb (Boschma 2005). With too little cognitive proximity or too much, the learning process can become too costly, in terms of time and transaction costs. Here the concept of the 'absorptive capacity' of a firm or organization (Cohen &

[16] The term 'cognitive' in this context refers to the specific knowledge base of a group of actors. Whereas the socio-cognitive context, although inclusive of the idea of knowledge bases (formal cognition), also includes perceptions, attitudes, values and norms (informal cognition).

Levinthal 1990) is relevant. There needs to be some cognitive proximity so that an actor, firm or organization can absorb new knowledge. There also needs to be some cognitive distance, so that the actor, firm or organization learns something new. Spatial proximity may affect both of these conditions. It could lead to a situation where innovation actors become engrained in their own cognitive paradigms resulting in cognitive lock-in. New ideas and information are then rejected due to their cognitive distance. Such lock-in could be brought about by geographical isolation, socio-political factors, regional power struggles, territorialism, or simply the choices of actors. In such a case, there might be a very strong 'local buzz' but almost no accepted external knowledge inflows, because:

> Knowledge mobilization […] relies upon the pre-existence of shared cognitive models of the world. Collaborative efforts in knowledge creation and exchange are facilitated among individuals who share values and identity. These features underpin the localised character of knowledge creation.
>
> (Malmberg & Maskell 2006:11)

Firms most often search first in their immediate spatial and organizational proximity for new information and knowledge relevant to them. This results in a high level of tacit knowledge particular to that firm or geographically-located cluster. Geographic proximity does play an important role in shaping the socio-cognitive paradigms of innovation actors. It also affects their cognitive proximities, and hence their ability to learn interactively (Boschma 2005).

Cognitive distance relates to the importance for innovation of external collaboration, such as global pipelines which would have an effect on learning and innovation in the RIS from a 'distance'. Cognitive distance may have an effect in the following ways: *Firstly*, it allows for novelty, which comes from external sources that may stimulate new ideas and new methods through interactions between individual agents and organizations. *Secondly*, it avoids cognitive lock-in, which may stifle the organization in the longer term, in the sense that 'routines in the organization (or in inter-organizational frameworks) obscure the view on new technologies or new market possibilities'...[and that]…'it may be difficult to unlearn habits or routines that have been successful in the past, but which become redundant over time' (Lambooy & Boschma 2001, cited in Boschma, (2005:64). *Thirdly*, cognitive distance avoids too much cognitive proximity and so reduces the risk of unintended knowledge spill-

overs. Therefore, some cognitive distance between actors in the RIS is better for interactive learning. As a general rule then, cognitive proximity is required for effective communication and is a pre-condition for absorptive capacity in the firm. At the same time, cognitive distance is required for novelty and interactive learning.

b) ***Organizational proximity*** – This can be defined as, 'the extent to which relations are shared in an organizational arrangement, either in or between organizations' (Boschma 2005:65). This role of networks and proximity is very important. Networks can be in the form of knowledge transfer or sharing cognitive proximities as described above, or they can be more tangible in the sense of partnerships, sharing market opportunities and so forth. Whereas geographic proximity assists in building networks and trust in and between organizations because of the face-to-face contact between actors, organizational proximity is a factor of the strength, number and quality of ties between organizations. Little organizational proximity implies few or weak ties to other organizations. At the other end of the scale, many and strong ties result in high levels of inter-dependence. In general, organizational proximity is important in the interactive learning process, especially when it comes to complex partnerships and knowledge integration. So while close organizational proximity is generally positive and necessary, it can also have adverse effects. First, it may lead to organizational lock-in, resulting in rigid decision making, loyalties, dependencies, and power structures in the relationship between smaller and larger firms. Secondly, it may result in contracts that prevent firms in the network accessing new networks and relationships which may improve their situation for learning and innovation in the RIS. In the end, loosely coupled networks are regarded as optimal for interactive learning. This is because they retain organizational relations (reducing the risk of uncertainty and opportunism in networks through organizational proximity). At the same time they are able to form new relations and partnerships that enable change and innovation in the network. In short, a balance needs to be struck between control and flexibility in organizational proximity for the purpose of interactive learning (Boschma 2005).

c) ***Social proximity*** – This is important to interactive learning in the RIS, because it is related to trust. Trust between social actors is needed in the interactive learning space to identify useful information and adopt it with the assurance that it will be used in a mutually beneficial or meaningful way. Trust is the opposite of opportunism. It is

built through social interactions. While it may come about through organizational and geographic proximity, it generally takes time to build up a relationship of trust. Close social proximity is conducive to high levels of trust, friendships, and experience, usually generated at the micro level of engagement (as opposed to the meso or macro levels where institutions and cultures are formed). Trust is thus an enabling condition for transfer of tacit knowledge, which is an important part of interactive learning. On the other hand, too much social proximity potentially harms the interactive learning process, as too much emphasis may be placed on the relationship simply because it is close. This may result in a situation where transactions between particular agents are preferred for the wrong reasons, and could result in a stagnation of interactive learning. This is another form of lock-in which may affect the ability of actors or organizations to make good choices regarding inputs into their learning and innovation processes. In sum, too little social distance may result in strained relationships and retard interactive learning due to a lack of trust, whilst too much social proximity may result in a situation of 'social' lock-in, where it is difficult to abandon current relationships for new opportunities. A balance between the two is optimal, and this balance can clearly be affected both positively and negatively by geographical proximity (Boschma 2005). Finally, social proximity is related to 'embeddedness', a concept which will be elaborated on in more detail below.

d) ***Institutional proximity*** **–** Institutional proximity concerns relationships on a macro or meso level, as described by Potts (2007) in his account of institutions from an institutional economics perspective. Formal institutions include formal rules, such as laws, policies and incentives. Informal institutions are things such as culture, habits, norms, language and routines. Socio-cognitive institutions are a type of institution, they are structured both formally and informally. They include formal knowledge as described above, but also informal knowledge that is learnt 'tacitly' and through association within communities. General institutional proximity refers to the degree of similarity of institutions, which may be carried by actors within a RIS, or different RISs. Organizational factors in the RIS are embedded in economic frameworks which, in turn, are embedded in institutional frameworks. Institutions and institutional proximity can make economic transactions easier by providing a stable environment of values and 'rules of the game' for interactive learning. Conversely, institutional distance may hamper these conditions of stability. It implies a degree of

incompatibility in values, norms and 'rules of the game' acting as impediments to interactive learning, and so affecting the rate and direction of innovation in the RIS.

To sum up, an effective institutional framework provides a balance between too much rigidity (to avoid lock-in and inertia of that framework) and enough institutional conformity to enable stable relationships (so that interactive learning can easily take place for the process of innovation). Lastly, geographic proximity plays a fundamental role in shaping informal institutions. The territorial or administrative dimension shapes formal institutions (i.e. provincial and national policies and laws) (Boschma 2005).

e) ***Geographic proximity*** – has in general been seen as a favourable condition for knowledge transfer and interactive knowledge in agglomerations or the RIS (Doloreux, 2002). In this section, the primary arguments of Boschma (2005) have shown that geographical proximity is not the only proximity that contributes to, or potentially hampers interactive learning through different forms of 'lock-in'. The assumptions about the direct influence of geographic proximity on interactive learning can be clarified in this sub-section. *First* of all geographic proximity is refined as a concept (in the light of the more nuanced definitions of proximity described above) to relate to actual spatial or physical distance between economic agents. This can be divided into both absolute and relative geographic proximity. Whereas absolute geographic proximity describes the permanent collocation of economic agents, relative geographic proximity relates to closeness in terms of contact: in other words, the role of networks and regular face-to-face meetings. Put differently, connecting does not mean that firms or actors need to be collocated, because travel creates the possibility of connecting physically. *Secondly*, geographic proximity does not always promote interactive learning simply because agents are collocated. In fact there are instances where closely collocated innovation agents do not interact, but rather interact in other networks, or as a community of practice in their sector. As suggested by Boschma (2005: 69):

> …social networks, based on personal acquaintances due to common working experiences, not only provide the main channels for knowledge diffusion, but also produce most knowledge. Furthermore, these social networks or communities of practice can also share tacit knowledge through temporary meetings, such as conferences, workshops or internships, as this still requires face-to-face contact. However, it would be wrong to suggest that knowledge spillovers are only as a result of spatial proximity – as social and professional networks are by no means spatially bound (Bjorn T. Asheim *et al.* 2011). They extend from the local to the global. This does not mean to say that social networks are not often spatially-based. But it brings one to the third point, that

> geographic proximity in most cases does matter and certainly does have an influence on the other forms of proximity.

It has been empirically shown that firms that are located near knowledge sources, such as universities often are or become more innovative (Boschma 2005). This is invariably as a result of knowledge exchange or knowledge spillover which requires some form of cognitive proximity in the firm as a capacity to absorb the knowledge and hence learn. Similarly 'ideal' agglomerations involve a combination of close geographic proximity with loose social and organizational ties and a strong cultural and institutional tradition for knowledge exchange and interactive learning. Loose social and organizational ties allow for a better learning environment as 'allegiances' are not particularly strong to one firm or the other. That means that new alliances can be formed relatively easily, stimulating new forms of learning as tacit and codified knowledge exchange. This kind of interaction is characteristic of a healthy, spatially bound innovation eco-system that is not limited to spatial proximity.

In some cases geographic proximity linked to a strong social proximity may result in a preference to keep information in 'insider-networks'. This can be detrimental to interactive learning and innovation. In the context of socio-cognitive institutions this may lead to parochial attitudes and resistance to change or outsider perspectives. An insider network continually choosing localised relationships and knowledge transfer above external or 'unknown' agents is an example of this. Such parochial attitudes impede new knowledge from entering the system resulting in an insular and rigid environment not conducive to innovation. One can call this spatial lock-in. It can be avoided by ensuring an open network, promoting access to external sources of knowledge. Several studies have shown that both local and external knowledge connections are important for stimulating learning and innovation (Boschma 2005).

As we have seen, geographical proximity can be complementary to all the other forms of proximity especially when it comes to tacit knowledge. Firms that are located nearer to each other have a greater potential for face-to-face contact, and a correspondingly greater tendency to trust each other to transfer tacit knowledge. However, geographic proximity, although important, is not the only form of proximity, and other forms should be recognised as important in the RIS. A better understanding of how proximities affect each other will assist in the potential design or management of innovation systems. That is why socio-cognitive institutions and their relation to the other forms of proximity are specifically relevant for this dissertation.

Coenen *et al.* (2004) have a different classification of proximities. They divide proximity into two kinds, functional and relational, making a sharper distinction than the multiple forms of proximity described above. A brief description of functional and relational proximity may be useful for references in the case study analysis. *Functional Proximity* is a blanket term used to describe the 'accessibility' between actors in a RIS. Functional proximity therefore takes transport networks and communications technology into account. In short it boils down to the ability of actors to interact quickly and easily. *Relational Proximity* is similar to organizational and social proximity in the sense that actors share a form of 'intangible' closeness through relationships (between actors and organizations) as well as similar values, norms or 'rules of thought and action'

2.5.5.3 Embeddedness

Embeddedness can be described as the social and cultural relationships of networks in a region. They, define the region beyond a territory, meaning the networks may extend beyond a geographic boundary. A similar concept to embeddedness is entrenchment, for example, entrenched ways of doing things, entrenched relationships, entrenched services or social consensus. Embeddedness shapes and represents the character, culture and institutional form or cultural landscape of a specific network in a region, economic space or cluster. This thinking comes from the industrial districts literature which has been described by Lyons (2000: cited in Doloreux 2002:251), as

> …embeddedness of firms is expected to strengthen the milieu by developing a sense of common industrial purpose and social consensus; common ways of perceiving economic and technical problems and solutions; and the development of extensive institutional and informal support that encourage innovation, skill formation, and the circulation among the firms.

In the literature embeddedness is primarily viewed as a social construct. It is a result of interactions between different agents in the RIS, which shape consensus or conditions for innovation exchange. Embeddedness can also be understood as integrated social networks, it includes the character of these networks as influenced or determined by the cultural and institutional frameworks that they are positioned in. Doloreux and Parto (2004) suggest that the cultural elements of regions, also form part of embeddedness. It is underlined by the institutional context, systemic interconnectedness and interdependency of a region.

Embeddedness of networks for example could be industry specific, they could be characterized as formal networks, or more informal networks. Embeddedness in the RIS,

could mean that the networks within it are integrated, and are shaped by the cultural and institutional context. This is described by Asheim *et al.* (2011:878) as follows:

> At the core of the RIS approach is an emphasis on economic and social interactions between agents, spanning the public and private sectors to engender and diffuse innovation in regions embedded in wider national and global systems.

2.5.5.4 Knowledge production and information flows

Knowledge production in relation to proximity is one of the most important mechanisms of RISs. New knowledge can be produced and reproduced in many different ways and derived from many different sources. Knowledge may be both codified and tacit: the former is more generalised or 'ubiquitous' and the latter more personal, experience-based and context specific. Both forms of knowledge are important to interactive learning in the ways in which they propel innovation in a region. These forms of knowledge are usually combined as interactive learning in the regional context. Optimizing combinations of knowledge, as 'know-what, know-why, know-who and know-how', according to Doloreux (2002), is necessary in innovation processes to build competitiveness in the production systems of firms and clusters. The different forms of proximity clearly influence this optimization. Interaction between agents with a degree of spatial and cognitive proximity provides a learning environment conducive to these combinations and hence produces new knowledge. Intra- and extra-regional networks and interactions also fulfil a vital role in knowledge production in the RIS. This has already been described above as local 'sticky' knowledge combining with global 'ubiquitous' knowledge (Maskell 2001). However, there needs to be a degree of localised absorptive capacity to recognise and interpret ubiquitous knowledge in the regional context and translate it into learning for innovation.

> In order for knowledge to be used to create economic value, it has to be coordinated with other knowledge. For example, knowledgeable people need to collaborate in order to produce, while specialized firms with potentially valuable knowledge stocked in their routines and competencies need to trade in order to realize its value. Just like the use of people's and firms' knowledge thus hinges upon their relations to other people and firms, so does the creation of new knowledge
>
> (Lorenzen 2005:400).

Lorenzen goes further. Although knowledge and learning may take place on the local to global levels, there are geographical patterns of knowledge accumulation.

> Because trade and economic development, to an increasing extent, are driven by knowledge use and creation, geographies of knowledge coordination and transfer reinforce – and possibly create – distinct patterns of regional and national specialization and growth (one notable result being clustering of economic activities in particular regions or cities).
>
> (Lorenzen 2005:401).

Geography influences the role that spatial proximity plays on tacit knowledge in a RIS. The role of tacit or 'sticky' knowledge and how it influences localised learning through social and cognitive proximity has up to now been a major theme. In many ways proximity features characteristic of RIS, can collectively describe the embeddedness of knowledge transfer, interactions and learning. However, although there has been some empirical evidence of the effects of spatial proximity, Håkanson (2005) explores to what extent this form of proximity effect is a reasonable claim. He highlights the continued vagueness of the concept of tacit knowledge and what the difference between 'codified' and 'tacit' knowledge really is:

> Tacit knowledge, it is argued, is difficult both to imitate and to voluntarily replicate. The converse is true for codified knowledge, which is assumed to 'flow' (nearly) without friction and (nearly) without cost.
>
> (Håkanson 2005:439).

In the past the idea of spatial proximity made a lot of sense, when forms of communication primarily required face to face contact, especially in a specific industry. However, in the modern world, with the advent of new forms of communication such as ICT, e-mail and the internet, a different technological context is 'embedded' in our societies.[17]. The counter argument would of course be that this still does not allow for the transfer of 'tacit' knowledge, and knowledge spill-overs in regional agglomerations. Actors in agglomerations or clusters sharing certain beliefs, faced with common challenges and commercial realities 'usually' interact and are believed to 'exchange' tacit knowledge and learning. This exchange is believed to be privileged to members of a closed network or localised group that is generally spatially collocated, and reinforced due to the low risks (due to trust) and costs of transactions (due to time) (Lorenzen 2005); and furthermore that it is impossible to transfer tacit knowledge over long distances as it requires a specific social context. Despite this general view, Håkanson (2005), arguing from a knowledge spill-over perspective, suggests that 'tacit' knowledge is not as 'sticky' or inaccessible as previously suggested. Innovation actors, especially in the same industry would have their own tacit knowledge and capabilities that would put them in a position to learn similar techniques or methods through a process of

[17] See Castells (2000) for a comprehensive perspective on the 'information age'.

trial and error, although 'time to innovation' may be longer when imitating as opposed to sharing directly through tacit learning. Finally, these small insights into the transfer of tacit knowledge still do not neglect the fact that tacit or sticky knowledge is more easily transferred or more readily available in a spatial location. This is reiterated by Håkanson (2005: 441) himself who is critical about the generalizations of tacit knowledge:

> …the competitive[ness] and other implications of both tacit and explicit knowledge crucially depend on the degree to which it is held privately or is collectively shared in the relevant epistemic community. Both through (voluntary) transfer and (involuntary) imitation, knowledge travels more easily in than between epistemic communities, the geographical distribution and organizational configurations of which are therefore crucial for the creation and diffusion of knowledge in both 'information space' (Boisot, 1995) and its geographical counterpart.

The final concept of importance to the argument in this dissertation is the notion of epistemic (scientific) communities. Epistemic communities form part of knowledge networks and bases. They are included as the formal element in cognitive communities, whereas informal elements are knowledge outside of academic or research disciplines (e.g. traditional knowledge, or spiritual knowledge). Another way to describe this is through what Coenen *et al*. (2004) suggest to be 'analytic knowledge bases' (formal 'scientific' knowledge i.e. formal SCIs) and 'synthetic knowledge bases' (societal knowledge i.e. informal SCIs). Socio-cognitive communities may include both analytic and synthetic knowledge. Analytic knowledge relates to exploration, or the scientific knowledge of universities. This includes knowledge from research and development in collaboration with firms. However, the character of this knowledge is codified, formal and ubiquitous. Synthetic knowledge on the other hand, has more to do with the recombination of existing knowledge, and includes a more general approach to knowledge for innovation. It is produced not only through search by firms, but also by interactions of actors in the RIS more informally.

Questions about what influences SCIs, their rigidity and their change are important. In some instances, it is localised tacit knowledge that leads to new and varied perspectives as isolated examples in niche environments. In other instances it is external knowledge bases that are accepted, having an impact on the current SCIs of a location or network in a RIS. Thus tacit knowledge can be translated into what Granovetter (1973) famously described as the 'weakness of strong ties' which may be locally based, and the 'strength of weak ties' which implies transfer of useful knowledge that may be both cognitively and spatially distant. In the latter, the extra-regional and extra-spatial connections and networks become especially important in the discussion about 'socio-cognitive' change.

2.5.5.5 Financing

Financing of a RIS, is regarded as an important mechanism by Cooke (*et al.* 1997). In short, financing matters in the ability of regions to innovate and directly affects their innovative capacity. Without access to financing, or with the political control of finances in a region, the more complex the RIS becomes. This affects institutional interactions on multiple levels. It is critical in the analysis of RISs to understand the dynamics of financing and the sources of financing. They may be local, regional, national or even international. But whatever they are, they have a huge impact on the nature, structure and ability of an RIS to perform competitively and to secure the required investments. Financing is a prerequisite for innovation and commercialization, but also for R&D. The direction of R&D is often decided by the financiers. Their investments vary, as controlled by financing authorities or the private sector. For example, certain kinds of infrastructure maybe required for innovation to take place in the region to support a specific industry. If there is little coordination or agreement between a central financing authority and the regional authority and they work at cross-purposes, innovation is hindered. Decentralising the financing of vital infrastructure, such as the communications network, allows the region to have a greater degree of choice in how it configures this infrastructure. Thus the degree of difference in budgetary allocations, and in the autonomy of regions or locations is an important factor in the characterization of RISs.

Cooke identifies three different kinds of financial systems which may have an effect on the RIS: (i) a system oriented to the market, where funds are allocated in a developed capital market, (ii) a system based more on credit, with considerable government regulation and control, and (iii) a system based on credit, with extremely little control and regulation (Cooke *et al.* 1997:481).

The first case implies minimal regional control, as it is based on a free market based stock exchange system. In other words, many firms would not seek financing from regional institutions. In the other two cases, the source of funding depends on the banking system as well as the regional government's financial jurisdiction. In some instances regional governments and regions have their own financial institutions and even tax systems (Cooke *et al.* 1997). The latter allows for the greatest degree of control in terms of spending patterns to stimulate or enhance innovation in the region. Having said that, it is important to recognise that regional systems can function just as well if they are appropriately controlled or influenced by national financial systems.

2.5.6 Summary and concluding discussion on RISs

RISs have many characteristics and features, described in some detail above, but the primary distinguishing feature of the RIS is the region as unit of analysis. RIS is a relatively new concept, and a review of the literature shows some differences in approach to it, ranging from a focus on the wider regional innovative capacity of a region, to a focus on the innovative capacity of firms in a region. RIS literature includes a general innovation systems approach, a focus on regional science and economic geography, an 'extra-regional' focus in terms of the connections and networks of the region, a focus on regional competitiveness, and a focus on the role of different types of knowledge in a firm's learning and innovation processes. It also includes more detailed descriptions of the elements and mechanisms constituting a RIS. These include firms, institutions, and 'knowledge, innovation and technology infrastructure' (KITI), which refers both to soft structures such as intermediary organizations and to hard infrastructures such as science and technology parks and R&D labs. Another element is regional policy which establishes the most responsive level for innovation. The final element is the region: its definition and administrative control are significant determinants of the character of a RIS.

The inter-related mechanisms of RISs identified in the literature review are *interactive learning, proximities, embeddedness, knowledge production,* and *financing.*

- *Interactive learning* is a vital process for innovation, shown to take place through vertical and horizontal networks.
- *Proximities* of various kinds play a major role in the learning process through observability, comparability and the neighbourhood effect. There are absolute (geographic or functional) proximities and relative (connectedness) proximities, or, in more detail, cognitive, organizational, social, institutional and geographic proximities. 'Local buzz' is a term used to describe local social interactions that stimulate innovation through face-to-face contact between innovation actors. Global pipelines also stimulate innovation through the transference of new ideas and knowledge into a local or regional community. Proximities are a key factor in the shaping and direction of an RIS, because they are central to the learning process, and particularly to the development of localised learning or 'sticky knowledge'. As opposed to ubiqitious knowledge, which is codified, sticky knowledge is dependent on local social interactions. Finally, socio-cognitive institutions are discussed in the context of the

different forms of proximity to explore how they may relate to the function of a RIS. In particular, proximities that are too close result in lock-in, and those that are too distant in missed opportunities.

- *Embeddedness* relates to the thickness of social networks in a regional context. This includes culture and entrenched ideals, practices and relationships.
- *Knowledge production* in the regional context is a mechanism central to RISs. The knowledge can be 'analytic' (science-based, R&D) knowledge, or 'synthetic' (recombination of existing knowledge), and it can be codified or tacit. Tacit knowledge is often a result of the local buzz. Without new knowledge, innovation does not take place. But knowledge production is not a sufficient condition for innovation. There needs to be a degree of absorptive capacity (through cognitive proximity) for transfer of knowledge to take place and issue in innovation in a RIS.
- Finally, *financing* is an extremely important mechanism of RISs, and understanding the autonomy of the finance mechanisms for innovation in a region is essential.

2.6 Sectoral innovation systems (SISs)

This section gives a brief overview of sectoral innovation systems (SISs), with a focus on distinguishing them from NISs and RISs. The primary difference between a RIS and a SIS is a narrower focus on the sector as unit of analysis. In this section, the perspectives of Malerba (2002), one of the initiators of the SIS concept, will first be explored, followed by additional perspectives from other authors.

Malerba defines a sector as 'a set of activities which are unified by some related product groups for a given or emerging demand and which share some basic knowledge. In a sector firms have commonalities and at the same time are heterogenous' (Malerba 2005: 65). The sectoral focus is rooted in four traditions: the *first* concerns change and transformation in and of sectors; the *second* is about links and interdependencies and the boundaries of a sector; the *third* tradition is the ISs approach, which explores interactions between actors and components in the sector; and the *fourth* involves the broad theoretical framing of the concept of SIS in an evolutionary perspective. Malerba (2002: 249) sees the evolutionary perspective as emphasising:

> …cognitive institutional dimensions, such as beliefs, objectives and expectations which in turn are affected by previous learning and experiences and by the environment in which agents act'. … [From that perspective] Heterogeneous firms facing similar technologies, searching around similar knowledge bases, undertaking similar production activities and 'embedded' in the same institutional [spatial] setting,

> share some common behavioural and organizational traits and develop a similar range of learning patterns, behaviour and organizational forms.

The evolutionary perspective on sectors focuses sharply on how technology decisions and choices are shaped by the institutional environment, knowledge base and learned behaviours (Malerba 2005). By contrast, in the interests of a broader understanding of the regional integration of different sectors, clusters and firms, the RIS approach is not as concerned with the actual change and internal dynamics of the sector itself. An SIS has a different focus on the 'products' and 'demand' of the sector in its definition, and the notion of a shared knowledge base. This is spelled out by Malerba (2002:250):

> A sectoral system of innovation and production is a set of new and established products for specific uses and the set of agents carrying out market and non-market interactions for the creation, production and sale of those products. A sectoral system has a knowledge base, technologies, inputs and an existing, emergent and potential demand.

The key point here is that knowledge bases and technological regimes provide powerful patterns of interaction between the actors and organization of innovative activities making them specific to each sector. Howells and Roberts (2000) provide a more in-depth perspective of this link between knowledge systems and ISs, stating how sectoral systems and knowledge systems interact and shape each other. The technological regime concept (Peneder 2010) is a central dimension in SISs literature, relating to the term techno-economic paradigm used by authors such as Dosi (1982) and Perez (1983). These terms can be seen as 'a particular combination of some fundamental properties of technologies: conditions favouring opportunity and appropriability; degrees of cumulativeness of technological knowledge and characteristics of the relevant knowledge base' (Malerba 2005:64).

Linked to the concept of technological regimes is a distinction in the character of innovative activities and market opportunities in sectors: what Malerba (2002) calls Schumpeter *Mark I* and *Mark II* models of sectors. *Mark 1* is characterised by the notion of creative destruction, technological ease of entry, and a big role of entrepreneurial activity and new firms in the innovation process. *Mark II* on the other hand, is characterised by large incumbents, who 'creatively accumulate' through building on their existing knowledge and technology bases. They maintain their competitiveness and dominance through continuous incremental innovation, and prevent smaller firms from entering the market. These advantages and barriers to entry for other firms are achieved through scale economies, continuous learning, financial resources, established markets and trade networks. This is similar to old industrial districts, except that here the positive benefit for sectors being well-established is revealed.

Established or entrenched sectors may also become technologically and economically path-dependent. Threats to large firms in Mark II sectors arise when there are rapid changes in the market, changes in the knowledge base or technological breakthroughs. These may make the sector transform to *Mark I*, characterised by turbulence and new smaller firms entering the sector promoting innovations and a new demand.

These insights into how sectors change are important for this dissertation, especially when the concept of threats to incumbents is extended to include external shocks, such as ecological shocks, that have an impact on the structure of the sector. This notion of environmental shocks external to the system will be taken further. A perceived need for socio-economic transitions or reconfigurations due to environmental externalities adds an interesting dimension to the sustainability transitions debate. It widens the scope from the understanding of transitions as purely socio-technical. The socio-economic includes the socio-technical, emphasising the impacts on the economic system as a whole. The case studies in this dissertation are sympathetic to the link between socio-economic and socio-technical. From this viewpoint, socio-cognitive institutions in innovation systems may be an equally important factor in socio-economic and technical direction. Socio-cognitive institutions are linked to knowledge systems, which in turn inform and influence technological systems. In the words of Malerba (2002:254):

> …basic knowledge and complementarities, together with firms' idiosyncratic experience and competencies, also affect agents' beliefs, visions or cognitive representations of the sectoral context (basic economic processes, technology, demand, users, suppliers, competitors and so on).

To conclude the section on SIS: They are similar to RISs, and SIS share the characteristics of interactive learning (knowledge production and transfer), embeddedness (in institutions) as well as interaction and networks between actors and organizations, as along with most of the elements and mechanisms discussed in the RISs literature. There is, however, a more prominent focus on the embeddedness of technology regimes in institutions in SIS, including the iterative dynamics between knowledge and sector development, retention and breakdowns. These breakdowns can be due to changing knowledge structures or external shocks shifting the technological trajectories of sectors, providing opportunities for innovation and new firms to emerge. Finally, the dynamics of SIS differ from sector to sector, as well as in different contexts and geographies. This can be linked to differences in the local knowledge base and socio-cognitive paradigms of innovation actors between regions. As noted by Malerba (2005:66), 'agents' cognition, actions and interactions are shaped by

institutions, which include norms, routines, common habits, established practices, rules, laws, standards and so on'. Innovation actors make up the competence and knowledge base of an SIS through internal learning processes, competencies, beliefs, goals, organizational structures and socio-cognitive paradigms. These aspects also generate a certain kind of sectoral lock-in and path dependency. It can transform through external shocks (crises, technological redundancies, ecological problems, laws etc.) and opportunities such as new market demands for sustainability.

2.7 Technological innovation systems (TISs) and functions of innovation systems

The most recent focus in the TIS literature is on how to build, shape and innovate towards new technologies for the purpose of achieving sustainable development. This line of thinking is deeply embedded in the ecological modernization debate (Hajer 1995), and is based on the notion that sustainability can be achieved through human and technological ingenuity, through guiding market economies towards more sustainable trajectories, and through 'modification' of the existing technological regime (Söderbaum 2007)[18].

The Swedish academics who first explored technological systems observed that innovation systems are often defined by a mix of technologies that cannot be restricted to national boundaries and are often international in scope. Technologies and their innovation extend beyond national borders, regions, sectors and clusters (Carlsson & Stankiewicz 1991). This led them to develop the notion of a technology innovation system (TIS).

A TIS is defined as:

> A set of networks of actors and institutions that jointly interact in a specific technological field and contribute to the generation, diffusion and utilization of variants of a new technology and a new product.
>
> (Markard & Truffer 2008:611)

The notion of a TIS provides a framework to analyse and assess technologies and provides a methodology for achieving some answers (see for example Markard *et al.* 2009). Despite the critique of an overly technological focus, TIS theory is explicit in describing a specific framework for assessing systemic contributions to technological innovation and its

[18] The ecological modernization concept is contentious, and in some instances is seen as a gamble between trying to exploit existing (natural) resources and doing so in such a way that it does not exploit the earth's socio-ecological systems beyond the point of no return (Brown 2011). Although this argument is fascinating, it unfortunately does not fit in the scope of this thesis.

development. Although it has been criticised as having an overly technological focus, TIS theory claims only to provide a more solid framework for assessing systemic contributions to technological innovation and development. However, in this regard, it is far less narrowly technical than the criticism suggests, moving beyond artefacts and products to an interest in processes, protocols and procedures (Bergek *et al.* 2008).

In this regard, the functional approach discussed next stems from a desire by researchers and academics to better understand the actual processes that exist in technology development. In other words, mapping out the components in the TIS is not enough. There is a need to systematically assess and analyse the processes that lead to technological innovation as an overall function of the system. The functional perspective is useful for analysis because it focuses our understanding of innovation processes also providing potential for a governance framework of innovation systems for sustainability transitions.

2.7.1 The functional approach to innovation systems

The functional approach, as the name suggests, tries to go beyond understanding the elements or components of ISs and their relationships. It tries to understand the core functions of an IS as a process (Bergek *et al.* 2008). This understanding acknowledges the various components and mechanisms, but tries to go deeper into understanding how an IS works or perhaps should work as a process. Such understanding enables actors (such as policy-makers) to intervene effectively and guide the system.

> The functions approach to innovation systems thus implies a focus on the dynamics of what is actually 'achieved' in the system rather than on the dynamics in terms of structural components only.
>
> (Bergek *et al.* 2008).

This statement suggests that the former conceptualization of ISs is too static. Even though the 'functions' are derived from a literature analysis of what classic NIS authors described as 'processes' and 'activities', what the 'functionalists' have achieved is to distinguish more clearly between a mere description of the components of the system and the generalised goal, process or function of that system. This serves as a useful tool or framework to assess these functions. A subsequent organization of IS processes, (although haphazardly presented in other IS literature), into a framework for comparative purposes is significant of the functional approach. TIS theorists were behind this organization so as to better comprehend

technological innovation. TIS is a far narrower and less complex concept of IS, as it focuses primarily on technology innovation.

Hekkert *et al.* (2007) suggest that understanding the functions of an innovation system would allow for a better manipulation of the system's [technological] outcomes or performance. This may be valuable for two reasons: *first,* improving the rate at which innovations are produced and so enhancing the overall productiveness and competitiveness of the economic system; and *second,* influencing the direction of technological change.

The functional focus is extremely important for SD, if innovations and new technologies are to replace older, dirtier and unsustainable production systems and technologies. Often technologies produce unwanted effects on the environment and society. If sustainability is to be reached a greater focus on sustainable technologies is required (Hekkert *et al.* 2007), so being able to manipulate the rate and direction of technological change towards sustainability through TIS thinking would also be beneficial. TIS thinking together with the functional approach may provide the market with a greater variety of technologies suitable for transition towards sustainability. Understanding the functions and sub-functions of ISs in general improves ability to achieve this. However, a word of caution is necessary. A limited focus on technology can stand in the way of sustainability transitions, which require the broader framework for 'change' argued for in this dissertation. TIS and the functional approach should be seen as important parts of this broader framework: of an innovation systems approach for achieving ST.

Although there is no universal agreement on what the functions of ISs should be, or how they should be classified there is some consensus on the general functions. Galli and Teubal (1997), for example speak of 'soft' vs. 'hard' functions which relate to the 'informal' vs. 'formal' descriptions of innovation systems mentioned above. These distinctions can be made as follows:

- *Hard* functions relate to: i) R&D ii) Science to business and administration services.
- Whereas *soft* functions could be described as: i) Diffusions of information, knowledge & technology ii) Policy making iii) Design and implementation of institutions concerning patent, laws, standards etc. iv) Diffusion of scientific culture v) Professional coordination.

Liu & White (2001) talk about five different functions, whilst Hekkert *et al.* (2007) mention seven, and the most extensive list, produced by Johnson (2001), gives eight functions. A more recent list produced by Jacobsson & Bergek (2011) also gives eight. These functions include: knowledge development and diffusion; entrepreneurial experimentation; influence on the direction of search; resource mobilization; market formation legitimation; and development of positive externalities. These functions and their explanations are expanded upon in more detail in Appendix B3.

The intent of TIS, in providing a framework to shape and guide new technological development for the purpose of sustainability fits neatly into the sustainability transitions debate.

3 CHAPTER 3 - Sustainability transitions (ST)

In this section a general overview is given of the theory of sustainability transitions (ST) over the last two decades. This is followed by more detailed explanations, commentaries and definitions of the central concepts associated with ST, ending with a discussion on ISs and STs. *Firstly*, the section provides historical and theoretical background perspectives on transitions and the multi-level perspective (MLP), a framework to comprehend socio-technical transition dynamics. *Secondly*, the concepts of strategic niche management and transition management are introduced in the context of contemporary transitions. *Finally*, the geography of transitions is a new dimension which is revealed as critical for understanding transitions and as particularly relevant to the analysis in this study.

Transitions are large-scale socio-technical system changes or techno-economic paradigm shifts. They have been achieved regionally, nationally and on a global level in societies of the past. Transitions are also taking place today: from old, redundant, unsustainable technical systems and infrastructures to new, modern and more sustainable systems. In many cases the technologies and associated changes in social practices started in specific geographic locations before they were diffused and adopted on wider geographic scales.

Some examples of past transitions include the shifts from: the horse drawn carriage to the automobile; sailing ships to steamships; cesspools to sewer systems; arable farming to mechanised farming; manual ship loading to mechanised systems; water supply in the Netherlands; the propeller engine to the jet engine in air travel; and more recently the emergent shift of coal-based energy systems to sustainable energy systems (See Geels 2006; Geels 2005; Geels 2002 for some of these historical examples).

The characteristics of these socio-technical regimes and their changes, were initially studied as transitions by a group of Dutch Transition theorists. Their insights stemmed from evolutionary economics, structuration theory, neo-institutional theory, sociology, and socio-technical studies. ST theory is grounded in both inductive empirical as well as deductive theoretical methodology in describing transitions of socio-technical regimes (Grin, Rotmans & Schot 2010). Theorists, including Kemp, Geels, Elzen, Hoogma and Schot, influenced government policy in strategic attempts to manage transitions in various sectors of their

economy towards sustainability.[19] Subsequently, sustainability transitions (ST) and transitions management (TM) have become leading theories in the enquiry into long-term transformative change and the comprehension and management of it. ST theory is in its early stages, but has the potential to develop into a more comprehensive approach and analytical tool for achieving SD. What follows is a brief introduction to the theory, with some emphasis on the most relevant insights for the study.

3.1 An introduction and background to transition studies

The study of ST can be classified into two broad themes or focus areas: The *first* has to do with transitions as they occurred in the past, or historical transitions; the *second* focuses on contemporary transition processes, their management and governance. Reviews of two prominent books on ST and a special edition of a journal provide cues to the organization of theoretical approaches below. The various topics and concepts under discussion are complemented by a variety of sources and author perspectives additional to those in the books.

The first book is *System innovation and the transition to sustainability: Theory, evidence and policy*, edited by Elzen, Geels and Green in 2004. The second book, entitled, *Transitions to sustainable development: New directions in the study of long term transformative change* by Grin, Rotmans and Schot, offers a collection of work in the field up to 2010. These books, along with the special edition of *Research Policy* on ST as an emerging field, provide a broad and long-term perspective on the emergence of ST as a theory. It is interesting to note that the research questions of both books are similar. They represent the research intent for the study of sustainability transitions as a whole. The questions asked in the first book are: 'How do transitions occur from a historical perspective?' and 'How can transition processes be influenced or induced (towards sustainability)?' The key questions remain effectively the same in the second publication: 'What is the nature of transitions?' and, 'How may we influence or guide them?'

In the first book emphasis is placed on a causal link between 'system innovation' and transitions. In the context of ST, 'conventional' innovation processes as incremental change are regarded as insufficient to achieve sustainability. Rather fundamental shifts in entire sectors and socio-technical systems are required if humanity is to achieve sustainability. The

19 For example, the 4th Dutch Environmental Policy Plan, introduced 'transition management' as official policy (Loorbach & Rotmans 2010).

required change is a shift by a factor-10 in ecological effectiveness (Elzen, Geels & Green, 2004; Geels, 2011). In some cases transitions and system innovations are used synonymously. In the context of 'system change', through investigation of historical cases, it was discovered that transitions don't occur because of singular factors of influence and change. Transitions occur rather as the result of multiple factors interacting in a complex environment, exercising influence on various levels. These authors contend that 'system innovations' leading to transitions contain at least the following general features:

> **Multi-actor:** they involve a wide range of actors, including firms, consumers, NGOs, research institutes and governments;
>
> **Multi-factor:** they are the result of multiple factors and their inter-play [inter-action], as opposed to single factors; they are a combination of technical, regulatory, society and behavioural change;
>
> **Multi-level:** they imply change at various levels – the micro-level of niches (new developments that do not initially fit an existing system), the meso-level of structuring paradigms and rules (regimes or systems), and the macro-level comprising wider societal and cultural characteristics and trends such as individualization and globalization;
>
> …and these types of multi-dimensional changes take a long period to develop.
>
> (Elzen *et al.* 2004:282)

As transition dynamics are difficult to comprehend in an unstructured way, the authors developed the multi-level perspective framework for analysis of the different structural levels and interactions. The MLP provides a sound theoretical framework to assess transition dynamics.

The key understandings of ST and TM in the second book, which was published six years later, emphasises a historical socio-technical dynamics, complex systems, and governance perspective on transitions. The authors divide their analysis into three units: i. *persistent problems* (which are unsustainable incumbent socio-technical systems), ii. *system innovation* and iii. *transition*. Transitions may take place through processes of *co-evolution* and *social learning*, through a *multi-level*, *multi-phase* and *co-design and learning* perspective (Grin *et al.* 2010). Each of these aspects is used to frame transition processes and is briefly described below:

a) **Co-evolutionary processes** in the transitions context, describes a set of co-evolving economic, social, cultural, ecological, technological and institutional sub-systems. Collectively these sub-systems shape each other and are able to co-determine a

transition. They involve the development of technological innovations and the generation of novelties, as well as the use and adoption of these in societies.

b) **Multi-level perspective** relates to the three 'scale' levels as structurations. From low to high these are: innovative practices (niche experiments), structure of existing systems (regime) and long-term exogenous trends (the landscape). Higher scale levels imply a higher degree of aggregation between the actors, structures and working practices.

c) **Multi-phase concept** relates to four phases: i. the *pre-development* phase from dynamic state of equilibrium in which the status quo of the system changes in the background, but changes are not visible; ii. the *take-off* phase or the actual point of ignition after which structural change begins to pick up; iii. the *acceleration phase* where structural change becomes visible; and finally iv. the *stabilization phase* where a new dynamic state of equilibrium is achieved. This latter phase is associated with complex adaptive systems.

d) **Co-design and learning** describes what happens when knowledge is developed in a complex, interactive design process with a range of stakeholders involved in processes of social learning. Constructing shared realities through learning processes requires frequent interaction with other viewpoints. This kind of non-linear learning also involves exchange of theoretical and practical knowledge and experience (Smith, Voß & Grin 2010:4,5).

These processes are inter-linked, and are compatible with ISs thinking, both in the evolutionary sense, and in terms of interactions between components and agents on different levels and scales and in different structures. Transitions by their nature imply radical changes in social and technical structures. While technology is a prime focus area of dynamic change, it can be reduced to an object. The socio-technical understanding avoids this trap, always seeing technology as embedded in social structures. Thus the socio-technical transition approach studies change as a material, social and cultural phenomenon which comes about through system innovation of socio-technical systems. As in ISs, this happens through interactions between different levels, components or 'organizational fields' in society which may include: 'the individual, organizational sub-system, organization, organizational population, organizational field, society, and world-system' (Grin *et al.* 2010: 12).

The most prominent difference between ISs studies and transition studies is the greater emphasis on complex adaptive systems and contemporary transition dynamics in the latter. The theories of MLP, ST and TM have developed further in the last decade, but have also become more integrated in their approaches to understanding, managing and governing transitions. After a decade of theoretical development, (Grin *et al.* 2010) place greater emphasis on contemporary transitions, developing TM theory further and providing examples of transition case studies. These studies start with 'persistent problems' in society and involve government agencies and multiple other societal stakeholders.

Socio-technical 'persistent' problems are often focused on 'urban' sustainability issues such as food, water, mobility and transport, health, energy and aging unsustainable infrastructures. They also include social aspects such as unsustainable consumption and production. 'Persistent problems' are the superlative form of 'wicked' problems that are inherently complex societal issues. They often don't have any specific starting point, and their causes are difficult to pinpoint.

> Persistent problems are related to the system failures that have crept into our societal systems and that, contrary to market failures, cannot be corrected by the market or current policies. System failures are locked-in flaws in our societal structures, such as technological bias, weak or dominant networks, institutional barriers, and path dependencies.
>
> (Rotmans & Loorbach 2009: 185)

Wicked problems are also associated with TD research and mode-2 knowledge production as starting points and focus areas. Mode-2 research has already been briefly mentioned in the context of ST studies as an appropriate form of knowledge production to solve persistent problems. Solving persistent problems such as climate change requires monumental transitions at the deep structural or social level. These pertain to knowledge production and reproduction, culture, virtues, norms and values and notably socio-cognitive institutions at various levels.

According to Geels (2011) achieving SD will require at least factor-10 improvements in current environmental efficiency trajectories in the next few decades. ST should thus by definition include a quest for a new value system on a global scale that plays out as socio-technical transitions, through system innovations on multiple levels and geographic scales (Grin *et al.* 2010). This value system, as altered SCI, should be in line with sustainability-oriented thinking.

The notion of a 'new value system' is of particular interest, especially when linking it back to the socio-technical unit. A new value system implies that current social practices embedded in technological artefacts and infrastructures are recognised as inappropriate for SD. This is a key message, signalling that change is required in a normative direction for sustainability. Such changes in socio-technical systems don't just occur, but must be driven by new policies, incentives, regulations, industry techniques, research and development, piloting, testing and prototyping – all of which are inherent features of ISs and their governance. It is for this reason that ISs and their geographic dimensions as explained in the RIS literature are important for ST.

Finally, as reported in some recent reviews of the literature in the special issue of *Research Policy Journal 2012*, four sub-theories or concepts have emerged over the years including: strategic niche management (SNM); the multi-level perspective (MLP); transition management (TM) and technological innovation systems (TIS) (Markard, Raven, & Truffer 2012). In the most recent literature, emphasis is being placed on the role of geography of sustainability transitions or (GOST) (Coenen 2010; Raven, Schot & Berkhout 2012). This latter focus on geography and spatial scales as opposed to structural scales in ST, is of particular interest in this study.

A better understanding of historical transition processes has provided insights into how to guide or 'induce' contemporary transitions. Sustainability transitions theorists view transition theory from multiple perspectives, leading to a variety of theories and understandings of transition processes. The historical and contemporary transitions focuses remain two separate but complementary approaches in the study of ST. Combining these approaches is valuable, providing different insights into the complex nature of transition processes for different circumstances and time-scales. Geels & Schot (2010) note that both global and local perspectives are prevalent in the study of transitions, through the MLP description of ST. Historical perspectives and lessons learnt of socio-technical transition dynamics inform to a large degree the notion of 'managing sustainable innovation journeys'.

3.2 Historical socio-technical transition dynamics and the MLP

Socio-technical transitions can be defined as: 'a set of processes that lead to a fundamental shift in socio-technical systems' (Markard *et al.* 2012b:956). Sustainability transitions then can be defined as the shift of socio-technical systems to more sustainable socio-technical systems – or 'long-term, multi-dimensional, and fundamental transformation processes

through which established socio-technical systems shift to more sustainable modes of production and consumption' (Markard *et al.* 2012b:956). A historical approach to the study of socio-technical systems provides the advantage of investigating complete transitions. This in turn provides insights into how current and future transition processes may work. No doubt, any theory that is developed from historical research needs to be tested against contemporary case studies in a reflexive manner to improve the theory. The MLP provides this opportunity for reflexive case study analysis (Grin *et al.* 2010).

Socio-technical systems can be divided into different sectors, such as energy supply, water supply, the waste systems or the transport systems of cities and towns. These systems are social as well as technical and are referred to as 'socio-technical regimes'. Transition theorists have traditionally had a strong focus on technological change in society (Geels 2002). However, sociological, evolutionary and neo-institutional approaches are considered in the change of one socio-technical system to another. System innovations refer to the change of entire social and technical systems embedded in society. They are crucial in the transition of socio-technical systems to more sustainable systems (Elzen *et al.* 2004; Genus & Coles 2008; Smith *et al.* 2010). However, these socio-technical systems may be rigid and resistant to change, locked-in as dominant socio-technical regimes in society.

Nelson & Winter (1982) first describe 'technological regimes' as being embedded in the socio-cognitive routines and configurations between practitioners, user groups and organizations. The concept of regimes is further elaborated on by Rip & Kemp (1998), who also include the social dimension. They define regimes as a wider set of sociological categories or rule populations. They don't confine them to social elements, but include institutions, policies, technology and infrastructure:

> A technological regime is the rule-set or grammar embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artefacts and persons, ways of defining problems; all of them embedded in institutions and infrastructures.
>
> (Rip & Kemp 1998:340)

The socio-technical 'regime'[20] is centrally important for ST studies. Regimes both represent barriers to entry of new technologies, and provide the resources and capacity for transformation (ie. through technological adoption and learning) (Smith *et al.* 2010). In this

[20] Hereafter 'regime' refers to the socio-technical definition.

sense, regimes can be seen as both enabling (providing the capacity for transitions) and constraining (through socio-technical lock-ins). These regime shifts, as complex dynamic transformations (Rotmans & Loorbach 2009) can be regarded as a 'typology of transitions'.

Technological transitions necessitate changes in social structures such as supporting institutions, behaviours, norms and values. For this reason emphasis is placed on social and technical as an inseparable, intertwined phenomenon. It becomes a single unit of analysis, of socio-technical in ST studies (Geels 2002). Another fundamental characteristic of socio-technical transitions is that they take place over an extended time period, in the region of fifty years. A time dimension is an inherent characteristic of the theory of ST. The transition of different sectors in society due to system innovations through time is fundamental to transitions research (Geels 2004; Smith *et al.* 2010).

Investigating historical transition processes through the MLP framework, has allowed authors to begin answering the first research question about them, i.e. how do historical transitions take place? In the empirical case application of the model, it was clear that the 'actor' played a central role, 'and that actual linkages always need to be made by actors in their activities and constructions of cognition' (Elzen *et al.* 2004: 284). However, the construction of 'cognition' is not limited to engineers and technicians who may be seen as responsible for continuing technological pathways of development. It is indeed the task of a wider network in society including multiple actors and stakeholders. This societal system can be seen as similar to an IS, as it includes similar components or 'domains' of science, policy, market, financiers, users, producers etc. This is reiterated by Geels (2002:1260):

> Technical trajectories are not only influenced by engineers, but also by users, policy makers, societal groups, suppliers, scientists, capital banks etc. [And] Because the activities of these groups are also guided by rules, I will use the term 'sociotechnical regimes' to refer to the semi-coherent set of rules carried by different social groups.

This comment is of interest because it recognises that technological change is a systemic process involving a wider group of actors. It also recognises that the stakeholders and societal groups create a 'set of rules' which relates to institutions in the RIS literature, and that users and socio-technical systems may be resistant to change. In such a case, the combination of regular users and socio-technical systems constitutes the regime as a rigid socio-technical structure. Whether or not it is rigid, the regime or incumbent socio-technical institution becomes a selection and retention mechanism. The regime actors decide where to steer the regime or which new technologies to adopt or reject. Depending on the rigidity or openness

of regimes, they can be seen as barriers (constraints) to change or as enablers of change. Regime actors that are open to interactive learning may create more malleable regimes, enabling change. The regimes they are associated with may rapidly endorse and adopt novelty, artefacts or new technologies. However, regime actors with fixed views and socio-cognitive paradigms may be slow or rigid to change (Smith, Stirling & Berkhout 2005a).

New innovations, technologies or 'artefacts' (niches) place upward pressure on regimes if they become more attractive alternatives. Regimes may adapt to adopt more attractive niches. Both regimes and niches are influenced by and embedded in wider socio-technical landscapes. These landscapes, as the term suggests, refer to rigid structures, 'as material and spatial arrangements' (Geels 2002:1260). They include physical integration of technology and society such as cities, towns, transport systems etc. (Elzen *et al.* 2004).

3.3 The multi-level perspective

Frank Geels, one of the main proponents of transition theory, investigates technological transitions as 'evolutionary reconfiguration processes' on different levels (Geels 2002). Several authors have described this as the multi-level perspective (MLP) (Kemp, Schot & Hoogma 1998; Kemp 1994; Rip & Kemp 1998; Van den Ende & Kemp 1999). Evolutionary economics proposes two views on evolutionary configuration processes, these are: 'i) variation, selection and retention, and ii) the creation of *new combinations* in Schumpetarian language, resulting in paths and trajectories of technological regimes or [structures]' (Geels 2002:1258). The MLP is a middle-range theory that incorporates the dynamic interaction between different levels or degrees of structuration. It provides a framework with which to analyse the overall dynamic patterns between these different levels of structuration as socio-technical transitions (Geels 2011). These range from a global level, which takes into consideration long durations of structural change to established regimes, to more immediate local level structural formations. The MLP is a framework robust enough to accommodate an evolutionary perspective, as it provides structural contexts in which actors, institutions and organizations act dynamically. These dynamics include on-going integration and re-integration between science, technology, policy, socio-cultural and user and market regimes forming 'deep structural' socio-technical regime systems characterised by lock-in. Regime rules as cognitive routines, shared beliefs, values, traditions, expectations (i.e. informal cognitive institutions) and capabilities, competences, knowledge preferences (i.e. formal cognitive institutions), user-practices, regulations, legal systems (i.e. wider institutions) are

determined by actors, but also iteratively shape actors' actions (Geels 2011). It is via this dynamic interaction that evolutionary mechanisms are at work, making up levels of structuration and determining their trajectory. These socio-technical regime contexts are non-linear, dynamically interacting levels of 'structuration' in society as the landscape, regime and niche constituting the multi-level perspective (MLP) (Berkhout, Smith & Stirling 2003; Geels 2002). Each level represents different degrees of 'hardness' and 'stability' in structure and populations of interacting elements (niches having the least and landscapes the most). The niche is the locus of radical innovations, where loose structures and small populations allow for experimentation, novelty and innovations to take place. The regime is the domain of established, entrenched and stable structures where mostly incremental innovation takes place. The landscape level is an exogenous deeply entrenched structure, which forms the background in which regimes and niches are embedded and influenced (Geels 2002, 2011; Kemp *et al.* 1998; Rip & Kemp 1998).

The MLP is useful in describing change processes in and between these different levels determining the transition. Transitions occur due to interactions between the various levels, understood to be 'nested hierarchies.' (More recently these configurations have come to be understood from a horizontal configuration rather than a nested one). However, in continuing the earlier view, regimes occur in landscapes, and niches occur and are embedded in regimes. This is described in more detail by Geels & Schot (2010:18):

> The (socio-) logic of the three levels is that they provide different kinds of coordination and structuration to activities in local practices. The three levels thus differ in terms of stability (and size). In niches, the social networks are small, unstable and precarious, consisting of entrepreneurs and innovators that are willing to take a chance. Actors need to put in a lot of work to uphold the niche. Because the rules (search heuristics, guidelines, visions) are diffuse, there is limited structuration of activities, much uncertainty and fluidity. Socio-technical regimes are more stable: social networks are larger; artefacts, regulations, markets, infrastructures, etc. have coalesced into stable configurations; and rules are articulated, clear and have more structuring effects. Socio-technical landscapes involve broader background structures that provide gradients for actions.

Further discussion of each of these levels ensues followed by a description of their dynamic interactions that contribute to socio-technical change.

The regime – The socio-technical 'regime' determines the stability of the socio-technical system in society. Regimes are a collective of economic, technological, infrastructural, political, institutional and social structures and rules incumbent in society. It is the shift from one regime to another that is of particular interest, and constitutes a transition. Geels (2011:27) describes a regime as a 'semi-coherent set of rules that orient and coordinate the

activities of the social groups that reproduce the various elements of socio-technical systems'. They are dominant paradigms of one or a combination of socio-technical structures, rooted in a prevailing institutional form that serves to produce societal functions. Regimes are inherently path-dependent and change incrementally (Smith *et al.* 2010). Whereas in the past, the concept of technological regimes, as described by Nelson and Winter (1982) focused on the determinants of technological trajectories as cognitive routines shared in a community of engineers, technological regimes as proposed by Kemp, Schot, & Hoogma (1998) place more emphasis on the rules of the selection environment (i.e. embedding of existing technologies in broader technical systems, in production practices and routines, consumption patterns, engineering and management belief systems and cultural values). Socio-technical regimes in ST theory include the 'softer' social and institutional structures, values, norms and attitudes in society. They refer to stable, embedded systems that are locked-into social, technological and economic structures. Smith *et al.* (2010) describe regimes as constituting the mainstream, as highly institutionalised ways of realising societal functions. The socio-technical regime thus includes the socio-logical categories of rules as dynamic interaction between different actors. They include users, scientists, policy makers, businesses, organizations and special-interest groups which form 'mutual dependencies' and known patterns of interaction (Geels & Schot 2010; Geels 2004).

Stability in the regime is created by three 'rules of structuration': cognitive, regulative and normative. **Cognitive** rules are a set of shared values, visions, norms, belief systems, search heuristics and directions of innovation. Collectively these reinforce a certain trajectory of development, leaving out possible alternatives. This structural dynamic is central to the notion of socio-cognitive paradigms and institutions. **Regulative** rules (regulations, standards and laws) may be difficult to change due to lobbying of various interest groups and embedded formal institutional arrangements in the economy that are difficult or slow to change. **Normative** rules refer to the values, behaviours and role relationships of actors (Geels & Schot 2010: 20). Geels (2004) suggests that three interrelated notions of socio-technical systems, rules and social systems can be used to interpret regime stability. *Firstly*, rules are seen as 'deep structures' that guide perceptions, and actions are seen as institutions. *Secondly*, actors and organizations are embedded in mutually dependent networks contributing to stability. *Thirdly*, socio-technical systems have an inherent material 'hardness' that makes them very difficult to change (e.g. coal power stations provide a stability to coal generated regimes). It should thus be noted that stability in this sense is not always a good

thing, especially in the context of aiming for STs. Furthermore, this is not only true for single big-infrastructures, but also the inter-dependence of smaller integrated technologies. Networked externalities of technologies arise when new technologies are produced based on the old technological structures serving to further lock-in the incumbent technology.

Whereas these structures may provide stability for effective functioning as institutions, they are also 'locked-in' to specific patterns of interaction, co-dependencies, legal contracts, financial investments etc. This makes the regime resistant to change, and rigid to novelty, viewed as a threat to incumbent systems in society. In these circumstances the regime is dynamically stable, and although innovation does take place it is not radical, but incremental (Geels & Schot 2010). A socio-technical regime can be likened to the Mark-2 type industrial sectors mentioned above that are dominant and resistant to change.

The role of power and agency should also be recognised as a determining factor in the formation of regimes, as well as their maintenance (Lawhon & Murphy 2011). Regimes create specific trajectories that are predictable not only for technological pathways but also for policy, science, industry, culture and markets. Social groups, with relative autonomy constitute the trajectory, as they share specific norms, values, experiences, perceptions, problem-agendas, knowledge bases and cognitive reasoning. Collectively these social group dynamics and interactions make up the socio-cognitive institutions of the regime. Competing socio-cognitive paradigms cause dynamic tensions in the regime. These tensions cause 'fluctuations' of trajectories (ie. of policy cycles, business cycles, cultural movements etc.), resulting in maladjustments in the regime. This leads to 'windows of opportunity' for transitions to occur (Geels & Schot 2007b).

Holtz *et al.* (2008) give a comprehensive description of regimes in the context of sustainability transitions. They define regimes from a review of the literature and summarise the characteristics of a regime as: i. *Purpose* – regimes relate to a societal function; ii. *Coherence* – regime elements are closely interrelated; iii. *Stability* – regimes are dynamically stable; iv. *Non-guidance* – they show emergent behaviour; and v. *Autonomy* – they are autonomous in the sense that system development is mostly driven by internal processes.

A regime is characteristically incumbent (in power), and wants to survive. Therefore, an industry regime may use its own resources to remain dominant as a socio-technical structure in its operational environment. The power of the regime results in various socio-cultural,

economic and technological 'lock-ins' which reinforce technological choices, behaviours, and perceptions in an institutional power structure. Lock-in refers to the socio-technical and organizational system that continuously supports certain infrastructure systems, products, services or technologies above others because of an 'inertia' or development trajectory.

The petrol and car transport industry is not only supported by people who buy petrol engine vehicles, but the whole infrastructure of refuelling stations, road networks, culture of driving etc. Thus it is not only the technology and infrastructure that dominates, but the culture of driving that reinforces consumer choices and behaviours benefitting the petro-chemicals and car manufacturing regimes. These are production systems that are reinforced by incremental innovations through the incumbent innovation system. For example, a new design of a car engine that is more efficient, reinforces the existing regime of the car industry. This innovation further locks-in consumers and users into using cars for transport, but also reinforces the need for road infrastructure.

At this point, it may be noted that production systems, strongly influence the trajectory and direction of search in innovation systems, in turn reinforcing trajectories of regimes. This may be problematic for STs, that require complete or radical system changes to achieve sustainability (Elzen *et al.* 2004). However, the IS coupled to the production system also has the required resources, and power to change the direction of regimes incrementally or radically. Often, the dominant production system also finances the IS, most often seeking thereby to avoid radical changes. If production systems are profitable and remain accepted in society, more radical sustainable alternatives will be avoided as there is no perceived need for change. This provides a wider socio-economic and ISs perspective on lock-in of regimes, requiring changes in the socio-cognitive institutions if this lock-in is to be broken. However, external shifts or shocks may lead to changes in the socio-cognitive paradigms of actors that lead to new SCIs supporting alternatives to the regime i.e. niches.

Niches – are seen in the ST literature as radical innovations or novelties that exist at the fringes of the regime or outside it as 'protected spaces'. The emergence of the new (innovations, artefacts or technologies) in niches occurs as a result of the dedicated involvement of a group of stakeholders creating a new market for the innovation. Niches in which new technologies can emerge and survive may exist in R&D labs, university environments, science and technology parks, and demonstration and pilot projects (Geels 2004, 2011), but they may also exist as geographic nodes of sustainability-oriented

development[21]. Niches are important because 'they provide locations for learning processes, e.g. about technical specifications, user preferences, public policies, symbolic meanings. Niches are locations where it is possible to deviate from rules in the existing regime' (Geels 2004: 912). Niches are usually actively co-constructed and protected by a network of actors who promote novelty in society. They don't just emerge by chance or through conventional market forces. Garud and Karnoe (cited in Geels 2004), have described this process as 'mindful deviation' and Garud and Ahlstrom see technological assessment as a socio-cognitive processes: 'one where notions of what is best are socially constructed and politically defined' (Garud & Ahlstrom, 1997: 26).

Protection and learning is afforded by either private or public actors including suppliers, development agencies, local authorities or users (Nill & Kemp 2009). Niches are often formed around new artefacts, technologies or processes that first take root in relatively protected environments and stimulate their development. There are three internal niche-formation processes: 'i. the building of social networks that carry, nurture and develop novelties; ii. heterogenous learning processes, to improve performance and build a working socio-technical configuration; iii. articulation of expectations and visions to guide learning processes and attract attention and funding' (Geels & Schot, 2010:22). Niches can be seen as sources of transformative power, but are enabled or constrained through interpretation by the more powerful regime structures (Smith *et al.* 2010).

a) **The landscape level** is characterised by deep socio-technical structures, rigid, slow to change, and not easily influenced by regime interventions and niche pressures. Rather, landscapes provide the contexts in which regimes and niches operate and landscape dynamics exercise a powerful influence on regimes and niches (Geels 2011; Grin *et al.* 2010). This refers to macro-trends and events from climate change, international markets, cultural trends and new scientific paradigms to more permanent socio-technical structures such as infrastructures in cities and towns, or the actual physical geography of a place. Niches and regimes initially were seen to be embedded in landscapes, but later revised to be seen as forming a hierarchical structure (Geels 2011). Regimes may in some instances be reinforced by landscape developments, and in other cases landscape developments may create difficulties for regimes to continue. Landscapes

[21] It is understood that 'niches' in the traditional sense do not refer to 'scalar' niches, this latter view is expanded upon in subsequent sections.

can be seen in several ways: as slow changes in environments, long-term shifts, or rapid external shocks. These difficulties allow niches or 'windows of opportunity' to develop and compete with regimes, or influence regimes to the extent that they have to adopt them (Grin *et al.* 2010; Smith *et al.* 2010).

These three levels are not static but continuously shift and adapt internally to external changes in landscapes. Niches can be considered as the 'seeds' of transitions, because they create the opportunity for alternatives to regimes to be developed. However, the success of niches in facilitating transitions is to a large extent dependent on both landscape and regime dynamics. The MLP provides a framework within which to understand such dynamic interactions between different levels. Niche-innovations build up internal momentum; changes at the landscape level place pressure on the regime; and this destabilization creates 'windows of opportunity' for niches to build more momentum and compete with the regime. This dynamic is shown in Figures 3.1 and 3.2 below. The first diagram shows the different socio-technical structures (landscape, regimes and niches) and how they may be embedded in each other.

To summarise: the niche level involves the micro-level structurations, with loose actor-networks and institutional configurations often associated with or supporting new innovations or technologies; the regime represents embedded, rigid and functional social and technical structures that are institutionalised to provide services for society; the landscape level refers to the context in which regimes and niches are embedded, making change or manipulation difficult. Landscapes generally represent slow or gradual change in macro-environments, but may include shocks that are uncontrolled and beyond the influence of both regimes and niches. While the original MLP is depicted below, the more dynamic model can be viewed in Appendix B4.

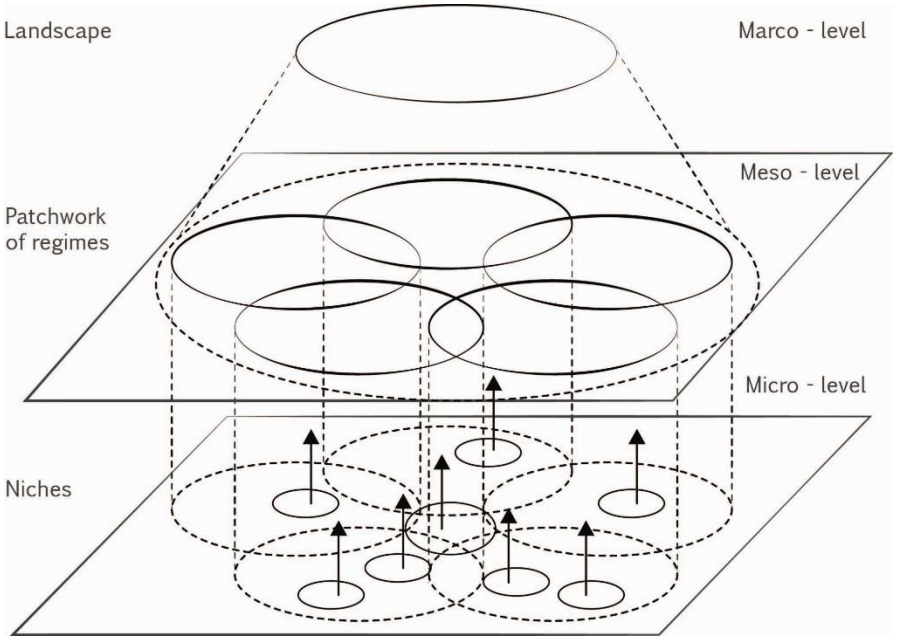

*Figure 3.1 A model of the multi-level perspective (*Genus & Coles 2008: 1437)

Changes, however, take place in regimes that represent the dominant socio-technical paradigm. As shown in the second diagram, these changes may arise from pressure on the regime by landscape developments such as shocks or increasing cultural or global demands for sustainable development. Either the regime adapts to these pressures, or eventually the pressure on the regime creates windows of opportunity for existing alternatives (niches) to replace the regime. Regimes themselves can also undergo pressures internally, and require change or restructuring for the following reasons: (1) users may change their preferences; (2) continued unchecked expansion of regimes may lead to environmental and social externalities prompting the development of alternatives; (3) regimes may be perceived as threats in society, leading to regulative pressures from policy makers and governments; (4) internal technical problems may be the cause of regime pressures; (5) competition and strategic games from other regimes and 'industrial populations' may put pressure on regimes (Geels & Schot 2010). These processes are not smooth or linear. As shown by the multiple arrows, multiple technological and social processes must be coordinated before a niche is adopted or replaces a regime. If and when a novelty receives the resources and societal support it requires to compete with or replace the regime, it creates a new direction for development in society (Elzen *et al.* 2004; Geels & Schot 2010). The study of historical transition processes does not take into account the normative direction of these transitions. However, the MLP framework, as described above, provides a robust theoretical framework

in which contemporary transition processes aimed at promoting sustainability transitions can be explored.

3.3.1 Theoretical background to global and local MLP dynamics

The MLP has been described above, as a middle-range theory that depicts the 'entire' transition process. A distinction is made between a macro, long-run 'global' model and a short run, micro 'local' model of transition. The global model potentially 'smooths over' dynamics that take place in the short-run or at the local level but are intrinsic and vital to the transitions process in the long-run. The use of the MLP from a long-term historical perspective downplays local dynamics as it is impractical to study actor dynamics over a fifty year transition. However, for the understanding of contemporary transition processes, and in the interests of managing transitions, the local level is extremely important (Geels & Schot 2010).

The local model of the MLP mirrors and includes the social and structural dynamics of interacting parts and local social interactions similar to those described in the RIS literatures. For a better comprehension of these multi-level dynamics and how they are related to the central notion of SCI in this dissertation, it is necessary to explore the theoretical background to the MLP, in particular the relationship between society and technology and the theories that underpin these dynamics. The MLP is a mix of different theories including:

> Evolutionary economics (trajectories, regimes, niches, speciation, path dependence, routines), science and technology studies (sense making, social networks, innovation as a social process shaped by broader societal contexts), structuration theory and neo-institutional theory (rules and institutions as 'deep structures' on which knowledgeable actors draw in their actions, duality of structure, i.e. structures are both context and outcome of actions, 'rules of the game' that structure actions).
>
> (Geels 2011:26)

The specific mix of theoretical backgrounds of the MLP (Science and Technology Studies, evolutionary theory, structuration and neo-institutional theory) hosts different assumptions. The MLP seeks to combine the various approaches to overcome these assumptions, and to create a single-integrated framework for studying socio-technical change on different levels. Science and technology studies (STS), structuration theory and evolutionary theories share similar assumptions, making for easier integration of ideas. STS theory assumes that creative actors interpret and socially construct meaning and cognitive frameworks. Similarly, structuration theory suggests actors interpret, but it also recognises structures such as routines on which actors draw to guide actions. In evolutionary theory, actors can be seen as passive

rule followers, but in different versions of the theory they are seen as able to create, learn, search and give meaning, as well as deliberately deviate from routines and rule-regimes (Geels & Schot 2010). Each of these theories and how it relates to the global and local levels of structuration is explained below:

a) **Science and Technology studies -** offers a critique of the linear understanding of technological determinism. This is its most valuable contribution. Technological determinism assumes that technology harbours its own 'internal' logic and momentum, separate from societal interactions, and sees it as changing society once it is developed and introduced. STS, by contrast, sees production and integration of technology in society as a messy and iterative process on a local level involving multiple interactions between actors and domains (e.g. Science, market, regulation and production). In this process 'particular outcomes and technical forms are ... not determined by an inherent technical logic, but are the outcome of agency and interactions between social groups and their choices, perceptions, networks and strategies' (Geels & Schot 2010: 32). The key contribution of actor-network theory (ANT) to this thinking is that actors act in networks and cannot escape the already existing integration with technology. Social Construction of Technology (SCOT) authors assert that technological change is a socio-cognitive process. Dominant designs are gradually accepted in society as shared meanings about the form and function of the new technology becoming established. Their selection thus 'coincides with the build-up of a shared cognitive frame' (Geels & Schot 2010:33). This latter notion will be important in linking SCOT to socio-cognitive institutions in ISs. A similar approach to the shaping of technological trajectories is found in an IS and RIS model. The dynamics of 'local social interaction' also advocates co-creation which may provide a novel perspective on the construction of 'dominant' designs leading to constructed trajectories for development. One critique of STS is that its understanding of the role of power and agency can be perceived as neglecting to view actors as embedded in the wider horizontal and vertical structures or institutions. This becomes plain in discussing the 'domestication' of technology, or the ways it is accepted, used and learnt about in society. In STS, the notion of technological creation and acceptance in society is seen as a social process of interaction at the local level. However, in transitions research, this needs to be complemented by a model that has scope for the global, understanding trends and changes from a long-term and macro-perspective (Geels & Schot 2010).

a) **Evolutionary economics (EE)** makes up for this shortfall in STS. It gives attention both to a long-term perspective and to the wider environment in which technology selection takes place, as well as maintaining a short-term perspective. The concept of technological regime in EE embodies both the continuation of a certain trajectory, and the notion of the structural embeddedness of actors. Furthermore, in EE the notion of retention is linked to the technological regime in which the routines and rules of actors bring about institutional stability. 'Technological regimes particularly refer to the search heuristics and cognitive routines shared by engineers working in different forms. Because of these routines, engineers in a technological field work in more or less the same direction, giving rise to technological trajectories' (Geels & Schot 2010:37). The market is seen by EE as the primary selection environment, where firms compete for scarce resources. Population of firms and trajectories are shifted through the selection of novelty, which is determined by new search or R&D processes.

b) This almost 'blind' selection process contrasts with the more sociological agency perspective of **structuration theory.** Actors are seen as intentional in their search for and generation of alternatives (as innovations). However, the intentions to create novelty are not entirely free, as they are embedded in operational environments with their constraining regime structures: rigid institutions, rules and routines. Having said that, regimes or institutions can also be enabling, in the sense that they provide the frameworks for actors to interpret externally. From this perspective sociologists argue that actors always observe and interpret reality through the frames of rules, routines, specific mental maps and cognitive institutions. In **structuration theory**, structures are thus seen as both enabling and constraining.

Geels and Schot (2010) add the following in pursuing a more holistic view of selection environments in the MLP: i. Technological trajectories are better seen as outcomes of interactions between guided search that is constrained and enabled by regimes on the one hand, and markets on the other. Sociologists extend the selection environment to include not only markets, but perspectives and religious and cultural views. ii. The generation of novelties should not be reduced to technical search processes. Geels and Schot adopt Levi-Strauss's term 'bricolage' to signal a wider conceptualization of rules and routines, expressed through heterogeneous alignments of local projects, including search and R&D. iii. Finally, there is an extension of the idea of what is being selected to include not only products in markets, but also bodies of knowledge. This includes the selection

of cognitive communities that may support the creation of new technologies, processes or techniques. Similarly, this type of selection may take place in the narrower selection environment of firms themselves. From this viewpoint, individual and social learning are important in the uptake of new cognitive rules forming new SCIs.

c) **Structuration theory and neo-institutional theory** provide further insights into the MLP primarily in their understanding of agency and structure. This again relates to the global and local level first mentioned above. Actors are seen to be embedded and influenced (constrained) by wider structures, but also as assisting in shaping these structures. This is what Giddens (1984) calls 'duality of structure', determined by 'rules and resources'. Rules refer to cognitive, interpretive frames and cultural norms. Resources are of two kinds: economic or allocative resources, which translate into control of 'things/money' and authoritative resources or control over people. The duality of structure thus refers to the way in which actors act out rules and apply resources becoming both the medium and outcome of action (Geels 2004). In summary:

> Actors and structures mutually presuppose each other: on the one hand, actors draw upon structures in concrete actions in local practices; on the other hand structures configure actors (belief systems, resource positions). Without structures, action would not be possible. In this sense, structures are not only constraining, but also enabling.
>
> Geels & Schot (2010: 42)

This latter description of structuration overlaps with the central notion of this dissertation - the view of *SCIs* as both enabling and constraining/hampering STs. This relates to the 'rule' aspect of structures as described here, but does not neglect the influence of power and resources on rules or SCIs. Furthermore, in structuration theory, emphasis is placed on the idea that actors are knowledgeable agents. They use rules to interpret the world, make decisions and act, but are also able to tailor them to local requirements and contexts. In 'local practices' different interpretations and creativity exist, allowing for variation. These perspectives again fit well with the notion of local social interaction, or 'local buzz' as described in the RIS literature. From a social perspective, actors and groups are both constrained and enabled by structures. Actor structuring refers to individual learning, which affects the individual or firm at the local level; alternatively social learning takes place at the more aggregate or shared-rule system level. Social

learning takes place through social interactions, through which social agents and social rules can be maintained or changed (Geels 2004). This maintenance or change can be seen almost as two competing phenomena:

> The individual, the strong personality as exemplified by Schumpter's entrepreneur or Hughes' system builder, enjoys an extensive freedom to act. In the second conception social actors are faceless automata following iron rules or given roles/functions in social structures which they cannot basically change. While the first view emphasises agency, the second highlights the effects of structures.
>
> Geels (2004: 907)

The different forms of proximity and local social interaction, most notably cognitive proximity, provide a differentiated insight into how structures at the local level may form in the context of global structures. Geels (2004) sees individual and social learning taking place through imitation and sharing of cognitive beliefs, both social processes; but he also sees it as taking place in concrete structures of embedded technological artefacts i.e. transportation systems or urban spaces. The latter emphasis on technological embeddedness emphasises the socio-technical approach, by contrast with RIS theory, which describes the mechanisms of local social-interaction as overtly social or cognitive. Although geographic proximity in RIS theory takes the physical environment of local social interaction into consideration, it does not refer to the influence of technological structures in the same way as constraining or enabling in the socio-technical sense.

Multi-dimensionality is further described in structuration theory. Giddens (1984) identifies three types of structure: i. structures of signification (meaning) ii. structures of legitimization (norms), iii. structures of domination (power). Neo-institutional theory provides a more 'operationalised' perspective of this multi-dimensionality describing effectively the same three kinds of institutions as 'cognitive', 'normative' and 'formal' (Geels 2004). These latter distinctions are of particular interest for this dissertation, because of the ways they relate to the notion of SCIs and how they are defined. The rules governing these institutions are not independent items, but are linked together to form semi-coherent sets of rules called regimes. Neo-institutional theorists have been interested not only in the stability of these regimes, but in the tensions and conflicts that bring about their change, for example the tensions between different and conflicting rules, and the conflicts between social groups and actors of different perspectives, values or cognitive institutions. 'Social systems' and 'social structures' are the terms used to distinguish between local practices as social interactions, and the

rules/institutions/resources in which they are embedded. Both systems and structures provide for directionality, or a trajectory, because actions and tensions have specific outcomes. These may be voluntary, as they are continuously changing in the social system, influencing change at the structural level. Conflict and strategic games, where actors battle for resources and power, may lead to transitions taking place more rapidly.

Two criticisms are levelled at structuration theory by Geels & Schot (2010): (i.) There is a general neglect of the role of technology in social life, and (ii.) too much attention is given to structures as opposed to social systems (ie. more attention is placed on vertical interactions between actors and structures than on horizontal interaction between actors). Furthermore, the agency-structure dimensions in structuration theory do not clearly articulate that macro-actors also play a role in agency through interactions. To overcome this dilemma, Hard (1994) and Geels & Deuten (2006) (Both cited in Geels & Schot 2010) have proposed local-global as an improved distinction. Finally, the morphogenetic cycle consisting of four processes through time provides an interpretation of how transitions may take place through the tensions between local practices and global structures (rules). Understanding these processes is important for grasping how changes in socio-technical structures may take place through time. Geels (2004) sees socio-technical structures as established through the interaction of cognitive, normative and regulative codes. These interactions and processes are explained below in the context of the rules that stabilise socio-technical systems: structural conditioning, social interaction, structural elaboration, and externalization and institutionalization.

a) ***Structural conditioning*** may be both enabling and constraining. From a cognitive perspective, it is enabling in the sense that it provides a framework in which actors may act and interpret the world. It is constraining, because this framework is both socially and technically integrated, locked in and resistant to change. The notion of proximities provides an additional layer of understanding of the enabling and constraining aspects of structural conditioning. For example, distant cognitive proximities[22] do not allow change to take place because there is a lack of 'cognitive capacity' for the uptake of new knowledge through local practices (Boschma 2005). Alternatively, too much cognitive lock-in may result in blindness to alternative techniques or knowledge bases, known as

[22] Please note that in this context the use of the term 'cognitive' here refers to 'formal cognitive' elements as described in the RIS literature, and distinguished in this thesis.

'deep structures'. *Normative rules* condition action, roles and structure through socialization, conformity pressure, social authority, rewards and punishment. *Regulative rules* create constraining environments for change. Interactions between normative and regulative rules result in variation (Geels & Schot, 2010).

b) ***Social interaction*** relates to strategic micro and macro games as local practices of actors which may eventually change social rules and structures. Change may come through the introduction of new search, R&D, investment decisions, entrepreneurial actions, new partnerships, new laws etc. Actors interact to try and further their own strategic positions in a 'game-like' manner (Geels 2004). This means that their actions are only rational if rules are stable, and information is available and transparent. In the games cognitive rules exist and are taken for granted or used 'unconsciously', allowing for creative interpretation, local constructions, and variety in local practices. Normative rules require that actors act according to expectations. However, actors may deviate from these expected behaviours through strategic games, or by re-interpreting rules. This allows for creativity and variety.

c) ***Structural elaboration*** suggests that structures may be changed or remain the same depending on selection which results in either 'reproduction' (of existing structures) or transformation (of rules and structures). This can be due to different forces or powers that act to maintain existing structures or enforce change. However, experience may lead actors to change their perspectives, with an effect on the eventual selection criteria. Such change may happen via *cognitive rules*. For instance, bottom-up learning processes, which imply community learning through interactions resulting in novel shared perspectives, may come about through experimentation, or through leadership by entrepreneurial actors in local practices that promote new ideas, practices, methodologies or inventions. Another instance is when global actors select on behalf of the field as a whole. The accumulated experiences of local practices can be identified by macro-actors as global knowledge or 'cognitive rules'. A third mechanism, included in the process of selection is the market. *Regulative* rules may also provide new selection criteria. For example, lobbying against or for pollution controls or other environmental externalities may be one way rules may change. Normative rules can change either relatively rapidly, through adjustments in social outlook, rules and responsibilities in day-to-day interactions. More extensive changes in values, cultural attitudes and codes of conduct may take more sustained influence over time to change.

d) ***Externalization and institutionalization*** refer to the actual acceptance and embedding of new rules, leading to new structures in society. In other words, they relate to the lasting impact and change that takes place due to rule changes on the local level. *Cognitive* institutionalization happens when new cognitive rules become the norm or are accepted in handbooks as the dominant learning paradigm. *Normative* codes are institutionalised when a wider array of actors, including authorities, endorse new codes of conduct, ethics, cultural values etc. *Regulative* institutionalization takes place when new laws or regulations are put in place (Geels & Schot 2010).

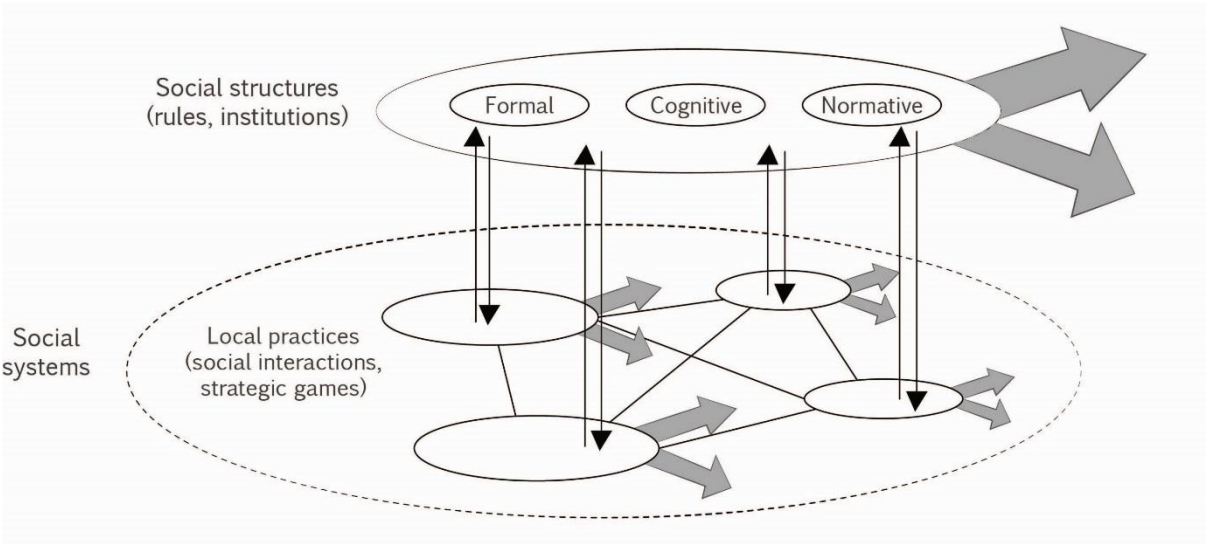

Figure 3.2 Social structures and social systems. Source: (Grin et al. 2010)

The integration of these different rules categories, takes place at the local and global level in a complex messy process. However, at some point stabilization is reached, which leads to a specific trajectory of rule categories. It is the trajectories that are determined by multiple populations or domains of science, policy, industry, culture, markets and technology development.

3.4 Contemporary transitions to sustainability

The usefulness of studying historical socio-technical transitions is that they provide insights into how contemporary transitions may be guided or steered in a normative direction such as SD. STs differ from historical transitions in certain respects. *First*, they are goal oriented, directional or 'purposive' in addressing 'persistent' problems. In contrast, historical transitions are regarded as having 'emergent' properties, in the pursuit of commercialization

by entrepreneurs. A *second* difference is that because environmental choices and sustainability solutions often take responsibility for problems in the environment, they become costlier than established systems. As they do not present immediate user benefits to the individual, such transitions will, in many instances, require adjustments in the economic and regulatory 'frame conditions' (e.g. taxes, subsidies, policies, governance structures) if they are to become more widely accepted. A *third* difference is that various sectors in the economy, like transport, food systems, and energy domains, are locked into a variety of often unsustainable economic practices. These sectors are often dominated by large firms, with established supplier networks, user practices, consumer preferences, sunk costs and investments, technologies and infrastructures which are referred to as 'complementary' assets. These assets not only lock the incumbent firms into established (possibly unsustainable) operational trajectories, but also crowd out smaller competitors who may be more sustainable. If these incumbent firms were to use their assets to support new entrants into the market it could 'speed-up' sustainability transitions. This would require structural change and adjustments in the dominant regimes, so that it is not business as usual. The MLP is a useful framework to show how novelty may compete with existing unsustainable systems or regimes, eventually transforming or replacing them to become more sustainable systems in society. One distinction from the technology push model, is that the MLP recognises that the destabilization of regimes provides 'windows of opportunity' for technological substitution (Elzen *et al.* 2004; Geels 2011).

Strategic Niche Management (SNM) and Transition Management (TM) are two approaches to achieve this. They try to establish if and how transitions can be influenced or 'induced' through actors, authorities or policies. The study of contemporary transitions for 'transition policy' is the second main research focus area of transition studies, suggesting ways in which transitions may be governed. They cannot be governed through direct steering of systems by a central authority like a government. Rather, indirect steering may be possible, through finding ways to 'modulate on-going dynamics'. Being able to make small initial changes to the direction of a system or to influence that direction may have longer-term consequences, so learning-by-doing is strongly supported by the TM approach, as is doing-by-learning (Grin *et al.* 2010). The direction of change is checked through continuous reflexivity and learning processes. TM includes a multi-actor and interactive model to predict where innovation actors are likely to interact in the process of transitions (Elzen *et al.* 2004).

In TM, the kind of interaction between actors and stakeholders is 'normative' or 'directional' towards sustainability, so is more than what is covered by IS theory. One critique of ISs theory, in fact, is that it neglects system transformation or change (Geels 2004). In TM, interactions are purposeful in their intent towards STs. The idea of intent of interaction and direction is related to 'vision building' in ST, SNM and TM work, a process in which direction of 'development' is decided upon by a heterogeneous group of actors. Visions and vision-building play an important role in this intent. They do not need to represent absolute consensus, but should at least reflect the inputs of a diverse group of agents leading to a new direction (Grin *et al.*, 2010; Kemp, Loorbach & Rotmans, 2007; Loorbach & Rotmans, 2010).

A more detailed description of the different concepts and approaches to sustainability transitions is given next. This will be important for part two, where the different theoretical approaches are discussed in relation to the analytical framework.

3.4.1 Strategic niche management

Strategic niche management (SNM) is an approach to STs that promotes the idea of change taking place through experimentation and the embedding of technologies on a small scale in society first. In other words, new technologies, processes or techniques are often started as projects on the periphery of regimes, by a group of researchers, innovators and, or entrepreneurs. SNM is one way to promote and support alternatives to the regime – eventually leading to a transition. Through support and 'management' of the technology in a 'protected' space it provides the opportunity for an innovation to compete in the wider market once protection measures are relaxed. Protection is required because there is a range of barriers to entry that the new technology cannot overcome without it. These factors include: cognitive and technological paradigms, and economic, social and cultural barriers. Of particular interest are the social, cognitive and institutional barriers to change and particularly to the adoption of new technologies. This implies a SCI shift in favour of the new technology, including: 'engineering ideas, management beliefs and expectations about the market potential, and on the users side, perceptions of the technology' which are highly subjective and differ across communities (Kemp *et al.* 1998: 183). Furthermore, niches require a specified space to take root, either in a geographical area or a protected market domain, technological experiment or the like. Niche's take place against the backdrop of existing regimes. In describing the concept of SNM, a distinction needs to be made between early

SNM work and later work. Early work emphasises niche-internal processes, whereas later work emphasises niches in the context of broader external environments (Geels & Schot 2010).

Kemp *et al.* (1998:186), early proponents of the concept, define SNM as:

> the creation, development and controlled phase-out of protected spaces for the development and use of promising technologies by means of experimentation, with the aim of (1) learning about the desirability of the new technology and (2) enhancing the further development and the rate of application of the new technology.

They also suggest that the management of niches involves several processes which may contribute to transitions. These processes, unlike conventional 'technology push' models, promote the idea of learning environments and articulation of the innovation and testing in real-world conditions for further expansion. Geels & Schot (2010) summarise internal niche processes into three different aspects:

a) ***The articulation of expectations and visions*** – is regarded as crucial to niche development because it provides direction to learning processes and legitimises continued protection. Niches may be strengthened through expectations that are more robust, more specific and of better quality standards.
b) ***Building of social networks*** – is important to create momentum, belief and support of the new innovation in terms of resources and buy-in. Success of niches is more likely if social networks are broader and more inclusive of a variety of stakeholders adapting cognitive frameworks. The depth of social networks and the quality of their ties allows for enhanced commitments to the novelty's success.
c) ***Learning processes*** – should include technical aspects and design, market and user preferences, cultural and symbolic meaning, infrastructure and maintenance networks, industry and production networks, regulations and government policy and society and environmental effects. Second-order learning, understood as change in cognitive frameworks and assumptions is also important. The broadening and depth of networks invoking second-order learning reduces the failure rate of niche technological adoption (Geels & Schot, 2010).

Niche formation on its own is not sufficient for transitions to take place, and the dynamics of the regime and the environment in which it is embedded play an important part in the acceptance of the technology. The various processes that are associated with SNM are:

a) ***The choice of technology*** **-** which should: have substantial benefits for society or the environment; have potential for overcoming initial limitations, up-scaling, replication and extension; be feasible in terms of organization and control, as a managerial and institutional pre-condition; already be attractive and valued as an alternative to the regime.

b) ***The selection of an experiment*** – involves choosing a setting or space for the technology to be further developed in context. There are usually conditions or geographic spaces where the specific technologies are more highly valued than others (for example a bus system in a highly congested city).

c) ***Set-up of the experiment*** – here a balance between the selection pressure and protection must be established, and choice of niche policies should be about assisting the niche to overcome barriers, including technological incompatibility, or economic non-competitiveness.

d) ***Scaling up the experiment*** – involves appropriate policies to scale up the technology or solution.

e) ***Breakdown of protection (by policy)*** – is a phased approach to allowing the new innovation or technology to compete naturally in the wider environment (Kemp *et al.* 1998). On this last point, there is some contention, as some authors suggest that new technologies or innovations have a greater chance of survival if exposed directly to the market without 'protection' (Hommels, Peters, & Bijker 2007). However, this is countered by the argument that the point of SNM is precisely that without 'protection' the innovation or technology will certainly not 'make it', and further that it is a strategic promotion of innovation that has a benefit to SD (Geels & Schot 2007a). More recently there has been a greater emphasis on the dynamics of protection itself, as opposed to a singular focus on the emergence of technologies in niches (See for example Smith & Raven 2012; Smith *et al.* 2014).

3.4.2 Conceptual niche management

In earlier SNM, the 'niche' development concept remained biased towards niches as technological innovations, and technology demonstrations were seen as advocating the

technology 'push' model (Geels & Schot 2010; Lawhon & Murphy 2011). This was countered by some authors, who suggest the need for emphasis on niches as 'concepts' as opposed to technologies (Hegger, Van Vliet & Vliet 2007; Monaghan 2009): a wider conceptual and social approach as opposed to a singular focus on the emergence of a technology. Such an approach then moves away from technological ideals that technological niches conquer the world as 'hopeful monstrosities': 'hopeful' because the new technology may enter the market, but 'monstrous' because the design of the innovation is crude and has not yet fully developed (Mokyr 2000). The wider conceptual approach includes vision, broadening social and stakeholder engagement, leadership, concepts of improved conditions, and social milieu and geographical environments in which niches are created and fostered at the grassroots level.

'Grassroots innovation' and social movements that are sustainability-oriented may provide important dimensions to conceptual niches. Technology is not excluded from this approach: it becomes a means to an end goal or concept. As opposed to a purely technological niche, these wider socially-inclusive niches aspire to achieving specific goals for sustainability associated with a collective vision which represents an alternative to the mainstream. This notion has been described by Hegger *et al.* (2007) as Conceptual Niche Management (CNM) as opposed to Strategic Niche Management. It has been built upon by (Monaghan 2009:1027), who has identified the following unique 'social' characteristics of such niches:

i. They exist in the social economy [ie. they are socio-economic rather that purely socio-technical]

ii. They enable social, cultural and ethical values that differ from those in the mainstream to be expressed. Their institutional form is pluralistic, characterised by a diversity of organisational types: voluntary organisations, local community groups, co-operatives (it is also possible to view local authorities as an additional institutional form).

iii. They have a similarly pluralistic resource base, ranging from voluntary contributions to grant funding. Their driving motivations are typically expressed through one of two social groups: a) 'communities of interest'— grassroots groups that 'define themselves as 'other' or 'alternative' to the mainstream' and are driven by 'an ideological commitment to a different way of doing things' b) 'communities of location'— grassroots groups that are based in a specific geographical location and are driven by a desire to meet a social or environmental need not met by the market, either because an incumbent system of consumption and production fails to serve a community or does not offer a choice that is desired by a community.

iv. They typically advocate social innovations: 'innovative activities and services motivated by the goal of meeting a social need and that are predominantly developed and diffused through organisations whose primary purposes are social.'

A critique of an overly technological approach to both understanding and driving innovations in niches is apparent in the literature. Niches can also imply that technologies are not only

developed by society (through innovation systems) and initially directed by societal perspectives (SCIs), but also adopted, experimented with, tested and learnt about in social-niche domains. The idea of 'normative visions of sustainability' as niches assumes societal-level conditions or cognitive influences resulting in technological change. These conditions may be a result of normative perspectives in realizing the drive for sustainable development alternatives. The conceptual approach and wider socio-technical approach includes the social and institutional processes that underpin the direction of technological development necessary to achieve sustainable goals. In other words, conceptual niches would:

> focus on concepts rather than technologies, enabling a move away from an emphasis on technology developers' designing solutions in response to a specific, structured problem to exploring how the potential of problem definitions may be improved at the societal level (Monaghan 2009:1030).

Another way to point out this difference is that ST and niche development possibly focus too much on the socio-technical systems and too little on their embeddedness in the wider social, cognitive and institutional elements of the socio-economic system. The socio-economic perspective implies that market forces influence choices through expectations of innovation system actors, and thus also the trajectories of innovation. Earlier consideration of STs may have been too focused on technological change in society, neglecting the drivers and forces of this change in the social economy.

3.4.3 An evolutionary socio-cognitive perspective on niche development

The sociological focus on how innovation and technologies are developed – in niches - goes a long way towards enabling us to understand how to promote thinking for the development, testing and embedding of sustainable technologies. Novelty does not occur in isolation and the social system that produces innovations may more readily be understood from an ISs perspective (Geels & Schot, 2010; Geels & Deuten, 2006).

From a ST perspective, it is vital to provide supplementary perspectives on how niches may develop and be protected, not only as technological alternatives, but also as alternative visions or concepts of future-states of more sustainable socio-technical systems/environments (e.g. urban environments). The role of technology in the transition to future-states led by visions for sustainability is crucial for the material changes that need to take place. This is true not only for the adoption of existing technologies, but also their creation. Whilst ISs have been criticised for not providing the directional 'normative' component for sustainability (Geels 2004), STs possibly lack the emphasis on the social, cognitive and institutional

systemic conditions for innovation processes. For this reason the niche development perspective of local social interactions forming into more aggregated or global knowledge, shared beliefs, expectations and visions is crucial for integrating IS and ST perspectives. ISs allow for a better understanding of how networks may function on the micro-level influenced by science, markets, and existing technological paradigms (Mina 2009). And socio-cognitive institutional formation on the global-niche level, may influence new conceptual/ technological niches as new shared sense-making (Makri & Lane 2007) which takes care of the directionality factors missing from ISs theory.

The directions of technology development are determined by scientific direction (search, exploration, R&D) (Makri & Lane 2007). However, investment, entrepreneurial actions, legitimization, leadership and above all (local) social interactions generate and support expectations of novelty as emerging socio-cognitive institutions. On this point, an important distinction is made in niche development between two levels of projects: in local practices and at the global niche-level. The global-niche level may be formed by a series of projects, supported by local actors who possibly share similar socio-cognitive paradigms. The rules shared between these actors are initially diffuse and unstable, eventually becoming more articulated, specific and stable (Geels & Schot 2010).

Cognitive rules are recognised to be influential in the increasingly shared trajectory of a series of projects, leading to a niche trajectory. Cognitive rules, however, are also influenced by existing normative and regulative rules. Although cognitive rules may change internally through internal niche dynamics such as learning or search, they may also be changed because of accompanying regulative conditions (e.g. new incentives providing opportunities) and normative rules (e.g. new techniques or conventions that are discovered). Furthermore, cognitive rules associated with new visions or guiding principles may develop in reaction to, or as a solution to, external regime-level or landscape-level dynamics. The point here is that SCIs that form at the global-niche level as alternatives to the regime-level SCIs are created and influenced by multiple factors, including internal niche dynamics at the project and development stage, and more formalised global-niche level dynamics influenced by external environments and dynamics.

Raven and Geels (2010) make some important points with regard to socio-cognitive dynamics and niche formation including learning, social network interactions, and changes in beliefs and perceptions which relate to SCI formation. Co-construction of new technologies

and projects involves both learning and experimentation. Real-life projects and demonstration projects lead to environments for learning, probing or testing new markets and exploration through experiments, piloting, prototyping, play, and risk-taking). In a learning context, 'SNM scholars have *analyse*d how sequences of concrete projects may add up to learning trajectories and lead to gradual changes in the context of knowledge, ideas and perceptions' (Raven & Geels 2010: 88). This is an important statement in the context of how SCIs may influence the trajectory of a series of projects. But this trajectory may also be shaped by wider societal goals, including 'sense-making' and aspirations for SD. Sense-making is important in the formation of trajectories on the global-niche level, as advocated in the evolutionary development of socio-cognitive niches. Human cognition is based upon individual cognitive frames that interpret data and meaning in the world. First order learning relates to data accumulation in a cognitive frame, whereas second-order learning is about interpretation and sense-making of this data, altering the cognitive frame. Cognitive evolutionary perspectives represent cycles of action, sense-making and adjustment of participants' cognitive frames. Individuals experience a variety of data and signals. They then select what fits their cognitive frames and reject the rest. Finally, they make sense of the selected data, which is then retained in the actor's mind. In this sense the process of variation, selection and retention is an individual social process making up cognitive evolutionary theory (Garud & Ahlstrom 1997; Garud & Rappa 1994; Raven & Geels 2010). A number of authors have published work on the notion of path creation as opposed to path dependence. This also involves a process of cognitive sense-making in technological choices. However, this sense-making is influenced also by the nature of the localised innovation systems, and the local social interaction that characterises them (Garud & Karnøe 2003; Garud, Kumaraswamy, & Karnøe 2010; Vergne & Durand 2010).

Linked to the cognitive-evolutionary perspective which focuses on individuals, and building on the explanation by Raven and Geels (2010), socio-cognitive perspectives require additional global dimensions to the notions of variation, selection and retention. The socio signifies a collective view in society, and moves towards a more aggregated and shared perspective of variation, selection and retention. The aggregate level of socially constructed cognitive perspectives - as opposed to the local individual, loose and heterogeneous cognitive perspectives of individuals in networks – forms the crux of the SCI perspective in this dissertation. This 'evolutionary' socio-cognitive perspective and how it relates to global-niche formation is embodied in socio-cognitive institutional formation. The processes are

similar for both global-niche structures and regime structures, except that in the latter SCIs are far more rigid, dominant and embedded.

In explaining SCI formation as an evolutionary cycle:

a) ***Retention*** – refers to aggregately shared perspectives and routines endorsing dominant design frameworks or technological regimes (the latter as described by Nelson & Winter 1982). The socio-cognitive level implies a degree of consensus among actors and emerging networks as to the direction of search, problem-solving strategies, theories, and testing hypotheses resulting in technological pathways. Through shared practical experiences of projects and testing, separate smaller communities (of practice) may come together, to gain insights and knowledge, and begin to develop theory around an emerging innovation, jointly creating a social and a cognitive community. This community of actors (such as a group of engineers) may become more and more stable socio-cognitively, leading to a global-level socio-cognitive institution usually supporting an innovation and/or technology (Geels & Deuten 2006). Actors of the global SCI may support the new innovation from a distance, and do not necessarily need to be part of the co-construction of the innovation itself. These actors may provide resources such as finance, or support the innovation politically but share or endorse the set of global cognitive rules or the alternative knowledge paradigm. (Geels & Deuten 2006) call this 'cosmopolitan knowledge': an abstraction of localised knowledge into standardised forms, which result in the aggregation of knowledge. Aggregation of knowledge is the process of transforming local knowledge into robust and transferable knowledge which is context-independent. This relates to what is regarded in the RIS literature as codified or ubiquitous knowledge as opposed to localised or tacit knowledge (Asheim & Isaksen, 2002). It is worth noting that the RIS literature also talks about local and global knowledge, but always links local to a geographic context. In discussing SCIs, local may refer to project level, and does not necessarily refer to a specific geographic location, even though the project may be geographically located. See Coenen *et al.* (2010) for a discussion on proximity. A distinction is made between codification of knowledge (ubiquitous knowledge) and aggregation, which mostly emphasises the 'de-localization' aspect. An additional point is that this process of aggregation results in a public good, which does not freely incentivise local actors to pursue codification for other's use. It is for this reason that, intermediary or professional organizations often assist in the de-localization or standardization of knowledge. Geels and Deuten (2006) are interested in

how a shared perspective of technical knowledge may come about, and secondly how this knowledge may become 'global'. This understanding is important for gauging how SCIs as global-niches become selection environments. Shared cognitive rules and perspectives act as stability and provide resources at a global level, but allow enough flexibility to meet local circumstances.

b) ***Variation*** - is made more 'sociological' by recognizing local projects as experimentation in communities of actors. They are able to deviate from existing rules and generate novelty. This deviation is not altogether random, however, as communities make normative decisions to search in particular directions or fund research for particular goals i.e. sustainable development. Visions and expectations are regarded as important in the variation of technological development. They can indicate the direction of innovative activities and local projects translated into search heuristics. Expectations are also strategically important, as they signal opportunity for resources, investment and political support. Furthermore, these expectations are in relation to the 'outside' world, of which the innovation becomes a solution. When changes occur in the outside world, potential exists for expectations about the innovation to shift again. Thus, 'expectations mediate between global cognitive rules and local projects and are influenced by the outside world' (Raven & Geels 2010:89). Innovations are determined by two inter-related processes of individual-level and institutional-level sense-making driven by three fundamental dimensions of a technology: its underlying beliefs, its physical artefacts, and its evaluation routines. These socio-cognitive processes between two levels first generate then narrow trajectories of innovation and technology (Makri & Lane 2007).

c) ***Selection*** – from a socio-cognitive perspective, involves group cognition and learning whereby local experiences become aggregated at the global level. Selection thus entails social learning which is understood as collective sense-making. Selection may occur in the social and institutional environment through competing ideals, research proposals, or presentations at conferences; through journals; or through project proposals. In this sense the cognitive direction is negotiated, competed for and selected. Selection of innovation and technological trajectories at the global level is thus a social and institutional process shaping the socio-cognitive directions of innovation (Raven & Geels, 2010).

What is discussed here, and relevant to the socio-cognitive perspective is that the evolutionary mechanisms of variation, selection and retention are not determined by markets alone, but are social and institutional processes. This is described in detail in Figure 3.3 below:

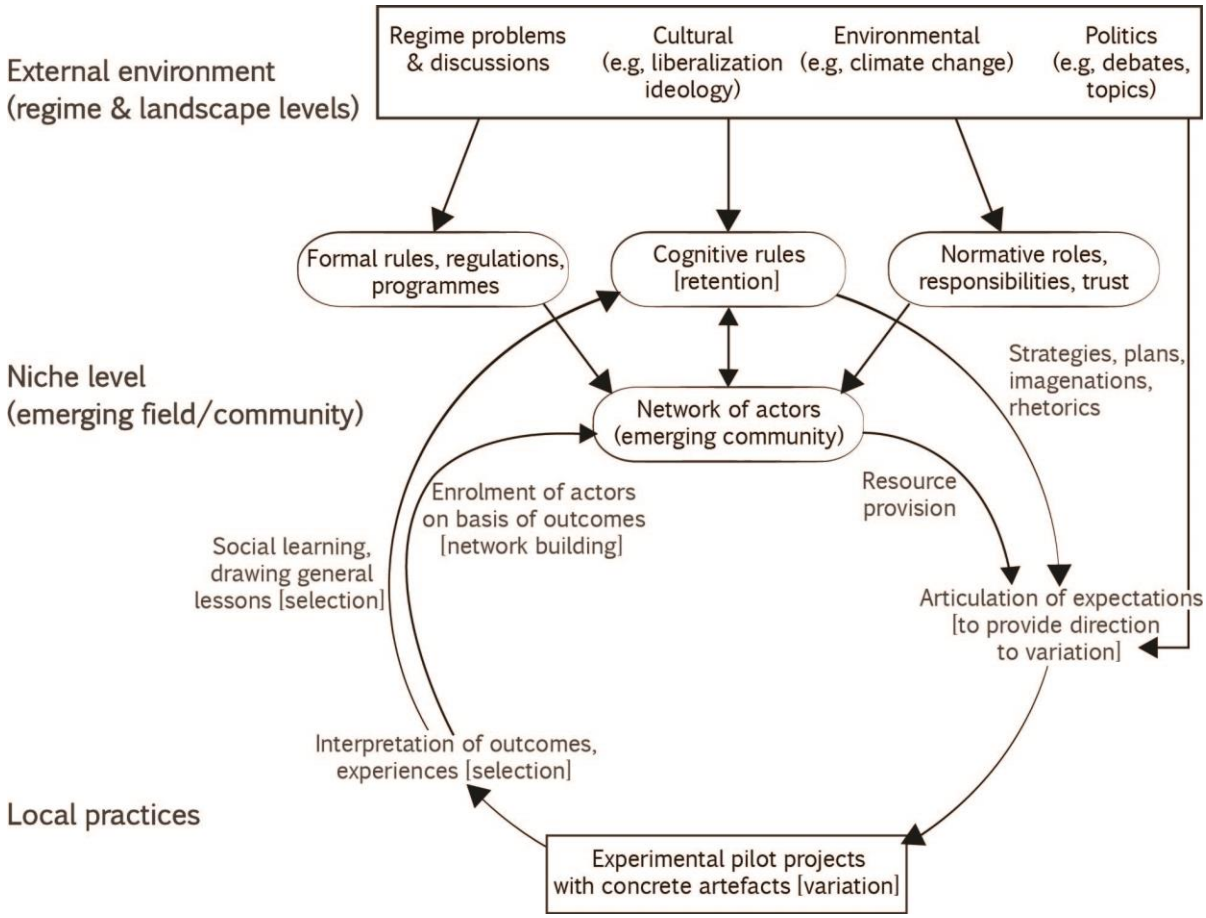

Figure 3.3 Socio-cognitive institutions and multiple levels (Raven & Geels 2010:90)

The evolutionary cycle of SCIs involves social processes leading to specific directions of IS outcomes, and the development of technologies that may be used to determine and achieve conceptual niches or visions of future-states of sustainability. In sum, while ISs have been criticised for not focusing on system innovation and normative directions of development, this can be overcome by introducing visions of future-states of sustainability into the *SCIs* of actors in the system. How alternative visions develop as wider social niche concepts is a matter requiring further investigation. Work on the role of the cognitive, normative and regulative rules that stabilise regimes has also been emphasised in niche development (Raven

& Geels 2010). Normative and regulative rules in this dissertation are seen as stemming from cognitive rules, as communal thought patterns (norms) and majority consensus (regulations or laws). An additional feature to the widening of niches, is the spatial or geographic context in which concepts may form and affect the cognitive, normative and regulative rules which support niche development. The RIS literature, the geography of knowledge, and local social interaction are particularly relevant for this discussion in section II and how they may be related to conceptual niches.

A better understanding of SNM through the lens of ISs, or RISs will also give a sense of how to support niche activities in creating sustainable alternatives to the regime. Niches are seen as vital to the transition process, but a wider understanding of the environment in which they exist, operate and which they eventually seek to replace, or integrate with, is required. Transition management, is specifically concerned with these dynamics.

3.5 Transition management

As opposed to the study of historical transitions, transition management is concerned with contemporary transitions and how to manage them. Like conceptual niche management, TM also advocates the 'vision' of actors as the starting point in a so-called 'transition arena'. TM recognises the 'transformative power of influencing cognitive frames', and has been described as 'actively aiming to influence the regime, using niche experiences and alternative visions to influence the cognitive frames of regime actors' (Geels & Schot 2010:84). In this sub-section a brief overview of TM is provided, followed by a discussion about regime change and transition pathways. It will be argued that the direction of transitions is ultimately determined by social, cognitive and institutional processes; but the capacity for transitions is provided by ISs.

Transition management is rooted in a complex integrated view of systems, which is coupled to a normative orientation towards sustainability. This stems from integrated sustainability assessment as a field of study. TM results from a co-evolution of theory and practice. The theoretical focus is on the non-linear dynamics between actors/agents, structures and practices. The practice part, from a management perspective, looks at how influencers with a coherent vision for sustainability may affect societal shifts towards sustainability. However, the possibility of 'managing' transitions is understood more subtly, as guiding or steering societal systems at different scale levels which may influence transitions to move in desired directions. TM takes 'persistent problems' in society as its starting point, and understands

itself as theoretically on a continuous path of development, between inductive and deductive approaches derived from transdisciplinary case study research (Rotmans & Loorbach 2010). What follows is a description of the TM approach with regard to niche formation and regime change. In this it differs from the MLP framework.

TM is based on the notion that a better understanding of complex societal systems will provide insights into how to direct them. This is because the management or governance of transitions is seen as essentially a social and institutional process. There is a strong focus on actors at and their interactions various scale levels, but above all their collective vision to achieve novel practices forming new, more sustainable societal structures. These new structures may support new technologies or innovations that represent alternatives to the regime or solutions to 'persistent problems'. The outcome of TM can be defined as a fundamental change in structure, culture and practice. *Structure* refers to: physical infrastructure; structure of economic elements, markets, consumption and production patterns; and institutions, such as rules and regulations (which are more formal institutional elements in TM). *Culture* as described in TM resembles the description of SCIs used in this dissertation: 'Our notion of culture refers to the collective set of values, norms, perspectives (in terms of coherent, shared orientation) and paradigm (in terms of way of defining problems and solutions)' (Rotmans & Loorbach 2010: 109). Finally, *practices* refers to collective routines in production, ways of handling, manner of implementation, but also self-reflection at the individual actor level. The dominant set of structure, culture and practices collectively forms the regime which seeks to reinforce stability. Niches thus represent alternative, novel and loose structures surrounding a technology or innovation, which try to organise themselves and compete with, or combine with, existing regimes. Two types of transition are distinguished: emergent and target-oriented transitions. Emergent transitions are associated with little co-ordination of actors, whereas targeted transitions are a result of high co-ordination of actors to achieve specific goals. This may range from a specific technology or sector in the economy to broader and more aggregate levels such as society, region or nation. These broad typologies of transitions are useful for describing the different levels at which transitions can take place.

a) In contrasting the 'pure' MLP perspective with TM, there are three transitions concepts of importance. These are the multi-phase, multi-level and multi-pattern conceptual approaches, which explain mechanisms, patterns and pathways of transition. The *multi-*

phase concept has to do with the timing, speed, direction and size of transitions. It describes the non-linear pattern of shifting dynamics in systems towards dynamic states of equilibrium. These are described in four processes as: i. the pre-development phase of a dynamic state of equilibrium in which the status quo of the system changes in the background; ii. the take-off phase: the 'point of ignition' when structural changes pick up momentum; iii. the acceleration phase where structural change becomes apparent; iv. the stabilization phase where structural transition has occurred and the new system finds equilibrium. These changes do not occur as neat or linear dynamics, but consist of complex, somewhat unpredictable processes and pathways. They may contain periods of slow and fast dynamics, usually over a period of 25 years.

b) The *multi-level concept* is also used in TM. However, there are differences in certainty about the number of structures or levels that they employ, as well as the dynamics between them. What TM recognises as useful from the MLP is the 'functional' dynamics between different levels of structure: the actors, the regime- and niche-actors, each with their own structure, culture and practices. At the niche level, as we have seen, learning processes between actors may take place, and ideas transform into possible alternatives to the regime. While the regime may initially be resistant to the niche, it can also provide the resources for the niche to succeed. In the TM perspective, this process is seen as essentially social, with the recognition that societal and actor perspectives and worldviews play a big role in transitions. Thus:

> from a micro-perspective, this means that a number of individual actors, so-called frontrunners (individuals, companies, local governments), can create stepping stones that make it possible for these actors to function as a catalyst for supporting the transition process.
>
> (Rotmans & Loorbach, 2010:132)

Thus transition pressures may come from bottom-up processes of niche formation, but they may also arise from discussions in regimes themselves in response to external pressures. These processes, from a complex, integrated systems view, do not agree entirely with a multi-level sketch of three distinct levels – rather they suggest that the dividing lines are more blurred and dynamic. TM authors add the notion of 'empowered niches' as niche-regimes which lie in-between the meso and micro levels; as well as the notion of an 'undercurrent' level which is a support/rejection canvas of citizens' perspectives – also having an effect on regime and niche dynamics. The *multi-pattern* dynamics of transitions refers to the

irreversible changes that take place in the system. These relate to various threats or opportunities that are created through niche developments, changes in the regime or external forces in the landscape. Both niche- and regime-actors respond to these changes, and embody different attributes of structure, culture and practice. In TM, these dynamics are regarded as primarily evident at three functional levels, the regime, the niche and the niche-regime. A *niche-regime*, as mentioned above, is a micro system that has grown powerful enough to challenge and take over from a regime. Sometimes several niches cluster together to become more powerful, forming a niche-regime. Various other patterns may emerge, which have been described as: i. A micro-meso pattern in which niches emerge at the micro-level, gain momentum and take-over from the incumbent regime; ii. A meso-meso pattern, where niches form in regimes and eventually transform those regimes; iii. A macro-meso pattern where sudden changes in the landscape lead to drastic changes in the incumbent regime (Rotmans & Loorbach 2010).

In the next sub-section these dynamics of regime change and how transition pathways emerge are briefly discussed.

3.5.1 Regime change and transition pathways

An alternative perspective on transition dynamics or governance is described by (Smith *et al.* 2005b) as regime changes that are the function of two processes: i. *The shifting of selection pressures bearing on a regime*, and ii. *The co-ordination of resources available inside and outside the regime.* The *first* process can be described as shifts in 'soft' factors : ideology, socio-cultural attitudes, norms, knowledge and socio-political and macro-economic landscapes. The *second* process involves the internal organization of available resources, and the harnessing of new external resources for the purposes of change, adaption or competitiveness. Transitions are a function of three factors: first, how the selection pressures of a regime are articulated in a particular direction; secondly, the extent of the resources available to the regime to be able to change or transform; and, thirdly, the co-ordination of responses to external or internal pressures of regime actors. Collectively, the latter two elements are known as the 'adaptive capacity' of the regime for transition (Smith *et al.* 2005a). The concept of adaptive capacity can be augmented from a RISs perspective. RIS theory looks at the notion of capacities in the context of regional, geographic and institutional embeddedness. However, it is also sensitive to the nature of local and global networks that lead to the absorptive and learning capacities of actors in the networks. These details are

currently missing from TM which would strengthen an understanding of capacity building as well as the spatial perspective on transitions.

The first process concerns selection pressures, which may be generated in various ways. New external knowledge entering the regime level creates selection pressures for a regime. As we have seen, the landscape level differs from the regime level in terms of structuration in that it can also put pressure on the regime which is embedded in it. That means that changes in the landscape often create new windows of opportunity for regime change (Elzen *et al.* 2004). For example, the phenomenon of climate change places pressure on the regime to find cleaner energy or less energy-intensive methods of production. However, the selection pressure on a regime to become more sustainable may be generated by more conventional regulatory mainstream economic tools, and is not necessarily the product of the eco-attitudes and sustainability-orientation of actors or industry. Such conventional regulatory tools could include incentives, knowledge flows, pricing structures, regulations, market opportunities and so forth. Conventional perspectives are usually limited to the firm level, whereas the wider perspective mentioned here, including landscapes, takes into account the entire socio-technical region. (See Smith *et al.* (2005) for a detailed description).

As in the MLP for the system transitions approach, the management approach considers that regimes can also be influenced from the bottom up, through strategic niches. Often these protected nodes of development are able to put selection pressure on regimes by providing better technology or services. The SNM approach advocates this strategy for transitions.

The second transition process concerns the co-ordination of resources, and so relates to the adaptive capacity of regimes: the ability of regimes to transform themselves and adapt, using internal and external resources.

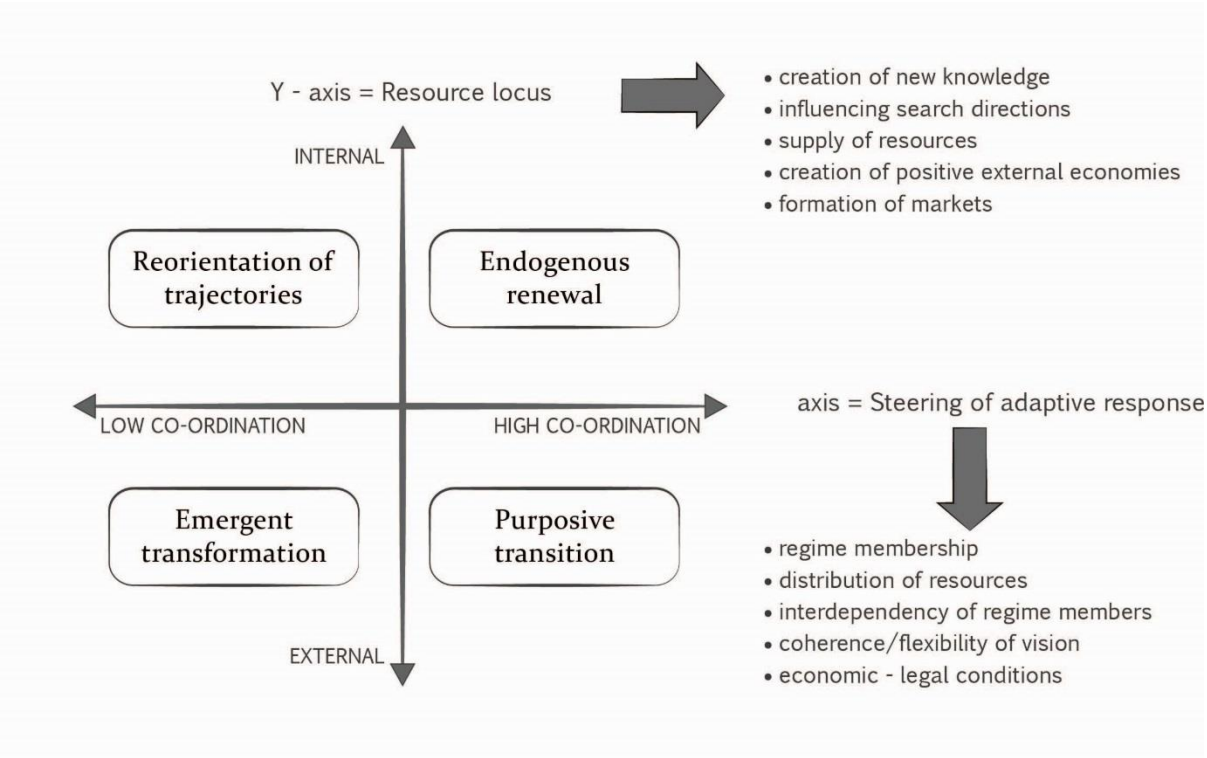

Figure 3.4 Transformation, transitions and trajectories (Smith et al., 2005a: 1499)

Figure 3.4 depicts four scenarios of how transition dynamics or pathways can be classified, providing a normative guiding tool for the governance of transitions. Governance of transitions through SNM, for example, is about recognizing the patterns that determine the most favourable shifts in a regime and this may help in that analysis. It is here that the 'normative' or ethical decision-making element inherent in SCIs is noted as important, and stressed.

a) The x-axis of Figure 3.4 relates to what is described as the ***adaptive capacity*** of the regime, and is marked ***steering of adaptive response***. The range is from low coordination to high coordination of responses. The *y-axis* presents the ***internal and external resources*** available to any specific regime. ***Reorientation of trajectories*** suggests low coordination of adaptive responses in the regime (Smith *et al.* 2005a). This suggests that the regime may respond to external changes in the environment, socio-political or technological landscapes.

b) ***Endogenous renewal*** results from high coordination in a regime as internal adaptation. This process can be described more as a transformation than a transition in trajectory[23] because the changes that take place in the regime are usually a result of

[23] For a more detailed classification of transitions vs. transformation trajectories see Geels & Schot (2007).

gradual innovation processes or incremental innovation rather than systemic innovation. There is no system overhaul or total shift but rather internal coordination of responses in the current system dynamics and processes (Smith *et al.* 2005).

c) ***Emergent transformation*** is described as an uncoordinated response through external adaptation measures. Thus the regime changes through external pressures or windows of opportunity without any internal organization between actors or members of the regime. These changes can also be explained as techno-economic paradigm shifts (Geels 2002; Peneder 2010), where new technologies are so impactful that they span multiple regimes, or even landscapes. GMO foods and the internet are contemporary examples (Smith *et al.* 2005).

d) The final quadrant describes external cooperation with a regime as ***purposive transitions***. A purposive transition is characterised by external actors to the regime, who supply the resources, networks and knowledge to enable change. This kind of transition is most closely linked with the conceptual ideals of transition management, which is highly specific in the sense that it follows a predetermined path, or vision. However, the various external landscapes and contexts change continuously making the process of management and governance of regime change challenging (Smith *et al.* 2005a).

In these four 'transition pathways' availability of resources, such as knowledge or required technology and infrastructure, is extremely important. In the case of limited internal resources, wider external networks become additional means of access to resources. This understanding, although not explicit, is familiar in the RIS literature. However, the explicit notion of the availability of resources through networks for specific purposes of transition to sustainability becomes a new focus for sustainability-oriented RISs.

In discussing 'transition pathways', the idea of capacity and capability building (from an ISs network perspective) for regime change to sustainability becomes interesting. Even more so, the spatially-based ISs proximity perspectives mentioned in RIS play a very important role in the access to and use of such resources. A spatial ISs perspective may assist in conceptualizing how to govern these enabling environments or learning regions, providing adaptive capacity for regime change. We now turn to the geographic perspective on sustainability transitions. It deals with some of these fundamental contextual and spatial quality arguments.

3.6 Geography of sustainability transitions (GOST)

Economic geographers have pointed to the potential that exists in bringing together economic geography, geography of innovation and sustainability transitions literature. They show how little spatial features figure in ST literature, which by association also leaves out social and institutional dynamics and the notion of proximities associated to learning, competitiveness and capacity building (Coenen *et al.* 2004). The RIS literature is particularly relevant in filling this gap. ST and RIS literatures complement each other. The ST literature provides a stronger goal-oriented and normative direction than is found in the RIS literature (Coenen, Benneworth, & Truffer 2012; Coenen & Truffer 2012).

In a critique of two strong analytical frameworks in ST, those of TISs and MLP, Coenen *et al.* (2012) highlight the neglect of a spatial perspective, and explain its importance , . In their critique of TISs theory, they comment that it started out with a strong conceptualization of the spatial dimension by Carlsson and Stankiewicz (1991), but that this dimension was lost in more recent work. This was possibly due to an emphasis on the 'functional mechanisms' in TISs, because 'the functional approach risks overemphasizing 'universal' (abstract) mechanisms as causal explanations for innovation at the expense of (real) embedded actor strategies and institutional structures' (Coenen *et al.* 2012: 970). This viewpoint is shared in this dissertation, in that the spatial dimension and geographic context contributes not only to the capacity, but also to the direction of SCIs of actors in the 'transition arena'. The transition arena is generally embedded both in a specific institutional paradigm and, contextually, in a geographic location. Geographic locations and scales are characterised by actor networks that are influenced by different forms of proximity (as discussed in section 5.5.2). The more subtle actor-network ties in proximity are to a large extent ignored in ST literature. They may provide significant perspectives on the formation of novel SCIs through knowledge sharing, learning, experimenting and exchange in proximity. It is reasonable to suggest that actors who share similar visions or concerns about 'future-states' come from similar communities, and local spatial contexts. It should also be recognised, however, that these conditions of proximity may have either enabling or constraining effects on SCIs. In the language of the MLP, proximities and local social interactions may translate into the enablement of new structures as niches through 'local actions'. These local actions may result in global communities of shared experience or visions for the future. Here it is argued that these local actions or interactions are often spatially based or geographically unique.

In the MLP, there is a lack of recognition of 'context specific' and 'socio-spatial' institutional relationships that may hamper or enable STs. Actors act in networks and institutions that are shaped both by localised interactions and by global dynamics and networks (Coenen *et al.* 2012). These important dimensions should not be neglected in theorizing why some regions develop capacity for transitions in certain directions whilst others do not. An example of this is given by Garud and Karnøe's (2003) account of the competition between Danish and U.S. American wind turbine development. These authors show a stark contrast in the approach to technology development. They treat U.S. approaches as characterised by a linear technology push model where the attitude of actors was 'techno-triumph'. Whereas the Danish approach was one of 'bricolage' or piecing together of prevailing technological and social capabilities that existed in the region. These capabilities were assumed to be regionally or locally specific, and led to a culture of collaboration, cohesion and integration of knowledge, capabilities and capacities. Despite the advanced engineering capabilities and R&D approach of the U.S., the bricolage approach of the Danish led to a far stronger wind energy sector (Garud & Karnøe 2003). The importance of this example is its highlighting of how local and regional co-operation, interaction and mutual learning results in the ability to grow a niche technology to market. Although the notion of embeddedness is seen as a factor, it is understood from a technological institutional perspective and the important nuances of geographic institutional proximity dynamics are missed (Coenen *et al.* 2012). Another important lesson is that cognitive institutions of individual actors are shaped through the gradual piecing together and advancement of the technology as a collective i.e. a form of social learning. This results first in a niche SCI, which becomes stronger and stronger to develop several wind turbine companies, eventually representing an empowered-niche SCI. However, returning to the critique from Coenen *et al.* (2012), they are wise to point out that the conditions of success in Denmark are associated with differences in systemic embeddedness of actors. What Garud and Karnøe (2003) neglect to emphasise is the spatial and various proximity dimensions that make these kinds of institutional interactions and learning possible.

As mentioned, the MLP is another analytical approach to ST that neglects the socio-spatial element. Although niches or local elements are expressly non-spatial in the MLP, Binz, Truffer, & Coenen (2014) and Raven *et al.* (2012) suggest there is considerable benefit in considering niches and ST from a spatial point of view. First of all, geography and different spatial scales come with their own characteristic institutional actor dynamics and interactions.

For this reason, adopting a multi-scalar approach, alongside the MLP approach can be beneficial to grasp these more socio-spatial and institutional processes. As expressed in the RIS literature, territorial scales play a role in the extent to which actors may engage both formally and informally. These interactions, and different forms of knowledge exchange, such as 'sticky' or 'tacit' knowledge (Asheim & Isaksen 2002), and local social interactions (Malmberg & Maskell 2006) have a certain role to play in STs (Coenen 2010). From a spatial perspective these are local interactions, though also possibly influenced by global dynamics. They give rise to spatially or geographically sensitive institutional dynamics. Such dynamics are relevant to this dissertation, important because of the context of shaping, and co-determining socio-cognitive institutions – which are already inherent in the MLP (Frank Geels & Deuten 2006; Raven & Geels 2010). Emphasizing the spatial or scalar dimension in ST is specifically important due to the variance in local (geographic and social) context conditions which have an effect on the ability of nations, regions, cities or towns to transition.

> There is a socio-cognitive difference but it is not that which is exclusively of importance: what matters about scale is that characteristics of the locality have different impacts on the processes at all scales, so even processes operating at a global geographical scale are influenced by differences in localities, mediated by the way they affect the 'local' flavor of the process.
>
> (Coenen & Truffer 2012:972)

The spatial dimension provides new perspectives on STs that are important for this dissertation for the following reasons:

a) Spatial contexts come with specific and varied institutional relationships that differ across geographies. This is important in recognizing why some places may be more amenable to ST than others.
b) The socio-spatial institutional perspective is closely related to the literature on RIS capacities and capabilities. This can and should also provide perspectives on the capabilities and capacities of certain geographies to transition more rapidly or easily than others.
c) Functional local and regional innovation systems, although capable, may not have the directional facilities embedded in the minds of actors or SCIs. The varied socio-spatial conditions and cognitive orientation of actors in RIS networks may provide a better understanding as to why some communities or regions favour change, whereas others do not. Some communities simply host the socio-cultural aptitude for change, i.e. in the creation or adoption of new more sustainable technologies, infrastructures,

processes, services or methods while others, through the support or rejection of more radical projects, promote sustainability outcomes such as new and 'unknown' infrastructure such as transport systems or energy systems, or waste systems, for example.

d) Socio-spatial institutions and interactions differ at different geographic scale levels. Local[24] interactions lead to a specific kind of socio-cognitive institution (which may include the more informal elements of culture, values and norms) whereas geographic- regional and global have different characteristic cognitive institutions. The former local SCIs may include tacit learning and be influenced through perspectives, community dynamics, politics and power, while the more global SCIs have none of these more informal but very important local conditions. It is for this reason that a link between SCIs and the geo-scalar approach should be recognised.

What is missing from the MLP structures is the link between local and global knowledge dynamics and its relation to different levels but then also geographic scales. Of particular interest is not only the emergence of novelty in the local scale-level, but its ability to influence and interact beyond its own borders to regional and global scale levels. It is here that the transition effects need to be understood as local, trans-local and global (Geels & Deuten 2006) but also from a scalar perspective expressed by Coenen *et al.* (2012:17):

> It seems self-evidently useful to look at the role of local as well as wider territorial networks in shaping the upscaling of niches to become or challenge regimes in particular places as a means of deducing new insights into what controls the pace and direction of transitions as both shifts in socio-cognitive orientations as well as the territoriality of key development processes.

Finally, institutional economic geography perspectives provide insights into how innovation and technology development may be enabled or constrained by territorially specific institutional characters. ''Institutional thickness' is one way of describing capacity conditions of different places, and also explains why some areas are more able to develop and adopt innovations. Some places have well-established, functional actor relations that create the conditions and capacity to support and establish new technologies or innovations while other places do not. In this sense thick institutions are enabling, whereas weak institutions are constraining as they have little co-ordination capacity. The notion of institutional thickness, is thus also important for ST. Institutional conditions and varieties are often place-sensitive, may be coupled to specific visions for development, and can explain why some regions have

[24] Please note, that local in this context refers to geographically local, and should not be confused with localised processes as referred to in the MLP.

greater abilities to transition than others (Coenen *et al.* 2012). These insights are particularly relevant to the problem statements of this dissertation. The concern is with understanding how ISs may provide capacity for STs at different levels, but also how local socio-spatial institutional conditions may enable or constrain socio-cognitive institutions that support STs at different levels. This notion of 'inter-localization' is captured by Coenen *et al.* (2012: 975):

> Therefore we can say that inter-localization need not be exclusively bottom up, but instead can also be coordinated in many localities simultaneously by a range of actors active across multiple scales. Inter-localization as a scalar shift involves qualitative transformation of the way particular processes (e.g. collective decision-making) function in a particular place, from being personal, negotiated and contingent, to institutionalised, transactionalised and generalised.

3.7 Conclusion and commentary of Part I: combining analytical strengths of ISs and transitions theory

This concluding section allows for a brief discussion of insights drawn from the literature review about STs from an IS perspective. Considerable potential exists for deepening and elucidating the strengths the different innovation systems theories and schools of thought may contribute to sustainability transitions. One aim of Part 1 has been to gain a broad understanding of the epistemological and ideological differences and similarities in the literature and how these have changed over time. An historical perspective on the literature captured the shift from innovation theory to a more systemic approach in IS theory. Another shift is also evident in the ST theory in the explicit emphasis on sustainability as a new academic project, or theoretical paradigm. ST theory is unique in that it draws from a wider body of literature, including innovation theory. That is why many of the epistemological and ontological characteristics of ISs theory remain in ST theory. However, ST theory has more to do with change in society in general, and more specifically with socio-technical systems than IS literature does. The latter provides a socio-economic view of change, with a greater emphasis on institutions, social learning and how interactions between components lead to innovation and change. These more social and institutional dimensions and insights from IS theory have not yet been fully integrated and used in ST theory.

Another aim, more simply, has been to introduce the various concepts and bodies of work that may contribute to an IS perspective on STs. Although the aim is simple, it is an important aspect of this dissertation. IS theory gives a rich perspective on the complex nature of innovation dynamics between society, state, government and academia. It also inherently

has a strong focus on the role of the economy and production systems and how this influences both lock-ins and new pathways for growth.

The most important aim is to show that ISs theory and ST theory are compatible, yet remain discrete in terms of their dedicated approaches to integrating their theoretical elements. The knowledge expressed in the RIS literatures is certainly valuable in gaining better insights into socio-economic capabilities for STs – and most notably because it focuses on social aspects of learning, proximities and geography. These theoretical perspectives can only add value to the ST literature, providing a dynamic theoretical base for innovation systems in the 21st Century.

A further aim is for the literature review to provide a rich background to the analytical lens defined in Part II. This analytical lens is intended to be the link back to the broader sets of literature discussed in this Part, and will be useful in the analysis when a broader theoretical perspective is needed.

Finally, the rationale for reviewing these two sets of literature is that, in the author's view, sustainability transitions by definition and in practical terms cannot be satisfactorily achieved but by combining the insights they offer.

Some of these aspects are discussed below in relation to the research themes for this dissertation, the focus of Part II, especially shaping the insights from the literature into a more focused analytical theoretical framework for the content analysis

Taking stock of the range covered by the theories that have been dealt with is important. This includes the historical review, as well as ideological differences over time in the theory of innovation. The primary ideological difference is currently between the ISs and ST literatures, in the sense that ST theory is overtly sustainability-oriented, whereas innovation and IS literature remains more 'mainstream' in its economic thrust. This is possibly due to ISs literature stemming from a tradition of economic growth and competiveness. A merging of ideological perspectives through bringing these two large bodies of literature into relation to one another has substantial merit in highlighting their features and raising new questions.. From an IS systems perspective, it provides rationale for a renewed focus on how ISs can provide the capacity for steering economies towards sustainability. From a ST viewpoint, greater emphasis can be placed on how ISs can provide the capacity for sustainable transitions, bringing into focus the localised and contextual features of proximities and

learning effects. These details, as described in the account of different forms of proximity in the RIS, are undoubtedly fundamental to transition processes. In addition, the depth of theory in STs supporting the notion of structures in society, provides greater insights into RIS.

Another important point worth mentioning is that without the capacity to enable or implement change through the selection of novelty, transition pathways would be constrained (and remain conceptual). Innovation systems theory tell us that transitions are to a large extent dependent upon a wider set of networked resources, environmental, social and economic and political contexts and milieux – all of which are usually embedded in certain regional or localised geographies. The RIS literature for example infers that transitions may be dependent on a set of geographically and institutionally contextual societal values, norms and cultures. More subtle forces and influences in systems of innovation may be at play in terms of influencing the direction of development as spatially embedded SCIs. Furthermore, transitions and the capacity of regimes to adapt are also mostly in contexts of power structures such as the wider socio-economic, socio-political landscapes.

The embeddedness of the regime in wider socio-technical structures or socio-economic landscapes plays a large part in determining its capacity and ability to transform or transition. ISs surely play a fundamental role in gaining access to new resources, developing alternatives through the enablement of innovation, and challenging external regime pressures or internal regime dynamics. The RIS literature highlights the extent to which these pressures are also dependent on the physical and geographic contexts of places, their networks, the thickness of their institutions, their cultures, and the capacity of their systems of innovation. It is thus strongly argued that transitions cannot be separated either from their immediate environments, or from wider social, institutional and geographical contexts. Ultimately, however, it is the local SCIs in ISs that support or reject novelties, no matter where the influence stems from. These novelties may support pathways to sustainability or conversely reinforce existing unsustainable socio-economic development. Therefore the governance, functioning and management of ISs can also be seen as essential to the governance of transitions.

In summary, the ability of regimes to transition is highly likely related to the innovative capacity of a place, region or nation. In part this can be determined by assessing or measuring the strength, weakness and general direction of the incumbent RIS. Although these

‘directions’ in ISs are multiple, and are often different for different segments of the economy, they signal tensions in ISs that may lead to wider socio-economic change.

Strong ISs may be locked into institutional structures that result in moving socio-economic systems away from the pathways to sustainability. Something else is needed that enables their direction towards sustainability. There are inevitably multiple factors at different levels and scales that influence the capacity, structure and direction innovation systems take. However, SCIs need to be investigated as one of the most powerful drivers of change in ISs leading to socio-economic change in spaces and places. Evidence of shifts can be measured, for example, in the emergence of new businesses supporting sustainability, or the adoption of new sustainable techniques or the implementation of new ‘sustainable infrastructure’. This will be tested in the case studies.

What is of interest in merging ideas from ST and IS literature is the concept of developing capacity for alternatives to the ‘unsustainable’ regimes. This can take place at multiple levels, from top-down policy structures to bottom-up geographically-based innovation projects. The point is that there is much room for understanding how capacities can be harnessed from an IS, and especially a RIS. On a macro level, ISs provide excellent frameworks for the strategic analysis of vital components in the economy that ensure growth and competitiveness. These insights can be tweaked for STs as the new goal. From a micro level perspective, like the strategic niche management SNM approach, considerable potential exists for a better understanding of new technology development, namely TIS, but also more generally as localised or RISs. The power of a multi-level perspective on innovation systems for the purpose of sustainability transitions is apparent. However, it needs to be better understood from a practical and political point of view.

For example, one focus area that needs to be investigated is the idea of niche developments as geographic or ‘locational’ innovation environments for sustainability. These may provide the necessary capacity and catalysts for transitions to occur on wider scale levels through regional social learning and innovation diffusion. Proximities are already known to play a significant role in these learning and diffusion processes, yet they have not been fully appreciated in the ST debate. For example, innovative localised enabling environments may create not only bottom-up pressures on regimes but could also have horizontal geographic ripple effects in a region. This may happen through learning, innovation and adoption of new technologies in proximity as alternatives to the regime. They could also be micro-markets,

which allow for the testing and showcasing of new technologies, methods and services. The problem, however, is how to establish such niche environments as societal constructs. In reality niches or emerging regimes face a host of social, political and economic barriers and pressures that often lock into place the incumbent regime, thus ensuring that the alternative regime or niche cannot compete or take-off in the mainstream market. These are some of the questions that need to be answered to further the sustainability transitions debate in academe, policy and practice.

PART II – *Chapter 4*

Design, development and presentation of the content analysis framework and methodology

Chpt 1 – Introduction to the dissertation

Introduction - *the dissertation's argument is outlined here, defining the notion of socio-cognitive institutions as inherent in innovation systems.*

Chpt 2 – Defining and contextualizing innovation, and innovation systems

Chpt 3 – Sustainability transitions

Part I – *An extensive literature review of innovation, innovation systems and sustainability transitions. Arguments about the complementarity of the literature is made in lieu of achieving sustainability transitions via an ISs approach.*

Chpt 4 – Design, development and presentation of the content analysis framework

Part II – *The literature review is converted into a deductive content analysis framework for the case studies, with a critical discussion of it. Methodology and methods are discussed.*

Chpt 5 – Introduction to the analysis process of case studies

Chpt 6 - Case 1 – SCIs, the RIS and socio-economic transitions of Styria (1970 – 2010)

Chpt 7 - Case 2 – 'Transforming Technopark' in the Western Cape Regional Innovation System

Part III – *An introduction to the organization of data, and coding procedures are given. There are four levels of analysis of each case study. Including coding of data texts from interview transcripts, inductive interpretation resulting in new categories or findings, ethnographic interpretation by the researcher as a narrative, and finally the researcher generalizes patterns in the findings. Each case was distinct, but collectively they contribute extensively to novelties in understanding the role of socio-cognitive institutions within ISs and STs.*

Chpt 8 - Discussion of the findings in the context of STs

Part IV – *this is the culmination of reflection on the findings of the case studies back to the research questions, so as to answer them. Recommendations for future research are also given.*

Part II – Chapter 4

Context in dissertation: *A critical synthesis of relevant literature, so as to develop a framework for the case studies analyses using a content analysis methodology.*
Aims: *This part has two aims and sections, the first is to critically synthesize and add additionally required concepts to develop the deductive content analysis framework. This framework is aligned to the three investigative themes of the dissertation. The second aims and section provides an explanation of the ethnographic content analysis methodology and the general design for the case studies.*
Primary argument and logic: *It is to develop theoretical arguments for Theme I: Analyzing the capacity of regional innovation systems. Theme II - SCIs as a determining factor for sustainability-oriented innovation systems (SoIS). Theme III - Multi-level structures and multi-scalar approaches in ISs and STs*

Dissertation orientation for Part II

The broader theoretical considerations discussed in Part I are integrated here to form a technical investigative analysis framework for the content analysis (CA) of the two case studies presented in Part III. This process is discussed in two sections.

The first section draws together elements from the literature already discussed, complementing them with new theoretical angles. These perspectives are summarized with the three investigative themes, propositions and research questions of the dissertation in mind. The analytical framework is presented and discussed briefly in relation to the investigative themes. How this analysis framework serves as a link between existing knowledge and new knowledge generation through the systematic investigation of the three themes in the empirical case studies is also explained. The framework provides structure for a systematic analysis, and hence presentation of the findings in Part III below.

The second section provides an explanation of the ethnographic content analysis methodology and the general design for the case studies. It explains the process of the research through a CA theoretical lens, translating the theory above, into an appropriate structure for the analysis. A deductive CA coding framework is derived from the literature. An inductive approach would be to analyse the literature, and by doing this select unique codes from the body of text. Both deductive and inductive methods are used in the analysis of the case study data. The aim of the CA is to validate the ethnographic findings and perspectives of the researcher. This dissertation also refers to the external phenomena of known events that further validate the researcher's claims.

Table 6 - Summary of structure and the research design elements for Part II

First section: Design, development and presentation of the analysis framework

- *Structuring of the literature according to the three investigative themes.*
- *Additional theoretical perspectives.*
- *Discussion of investigative themes 1-3, and developing theoretical lenses for them.*
- *Construction of investigative lens to sub-propositions and research questions*
- *Summary table showing development of deductive theoretical content analysis CA framework and associated authors.*
- *Conclusion and discussion of theoretical content analysis (CA) framework*

Second section: Content Analysis methodology, process of investigation and analysis

- *Background to ethnographic content analysis*
- *Content analysis procedures and process including design, data collection, data analysis*
- *Explanation of three approaches in the analysis – deductive, inductive and ethnographic*

In the first section, the ordering and structuring of primary theoretical insights allows for a critical reflection in line with the primary arguments of the dissertation. There are three investigative themes that translate into propositions, which in turn are used to guide responses to the RQs. The *first* investigative theme is to assess how ISs may provide capacity for STs. This requires additional insights into the differences between strong and weak ISs, especially for the purposes of analysis. The *second* investigative theme focuses on the role socio-cognitive institutions (SCI) may have in affecting the functioning and direction of ISs, and how they may both enable or constrain new directions for ISs and thus sustainability transition pathways. Here an important argument is made for the link between the direction of innovation and STs. ISs that are functional or strong are not necessarily sustainability-oriented, nor do they necessarily lead to STs. The notion of a wider conceptual perspective on transitions as not only socio-technical but also socio-economic is introduced. This brings the argument to the *third* investigative theme, which seeks to contextualize the previous two arguments in terms of different levels of structure, but also in relation to different scalar and proximity dimensions. It is important to recognize here that this investigative theme is viewed from a RIS perspective as the primary lens to investigate socio-economic change dynamics. However, throughout the analysis, the researcher has in mind STs, which is then discussed in the final Part of the dissertation, after the analysis is completed. Each investigative theme is associated with two research sub-questions (except theme 3), the findings of all of which will

be brought together to answer the primary research question, and lead the discussion in the final part of the dissertation.

The RIS literature strongly associates socio-spatial structures within different forms of proximity, and here spatial proximity is explicitly included in the analysis framework[25]. In brief how different forms of proximity affect learning and socio-cognitive institutional change for sustainability at different structural and scale levels is the primary focus of the investigation.

An aim is to compare the findings of the cases with ST theory during a post analysis phase. This is left to the discussion section. ST theory, although dealt with in the literature review above, is purposely excluded from the analysis framework, the purpose of which is to gain a purely ISs perspective on STs. Thereafter, the findings are discussed in the context of ST theory, and recommendations are made. The researcher did not limit the post-analysis comparison of the findings to socio-technical transitions and includes socio-economic transitions as a broader problem area.

Three propositions, associated to the RQs give direction to the investigative themes:

- When ISs provide capacity for economic growth, they also potentially provide capacity for STs.
- Socio-cognitive institutions within ISs can be enabling or constraining for STs.
- Socio-cognitive institutions are shaped and influenced both socio-structurally and socio-spatially.

[25] The author is well aware of the dangers of associating the MLP notion of structurations with spatial dimensions or geographic scales. However, the RIS literature allows for this discussion through the theoretical framework of proximities. This approach avoids theoretical deadlocks in the investigative framework for CA. But the focus on spatial and structural levels and STs from the RIS perspective is also explicit.

4 CHAPTER 4 – Design, development and presentation of the content analysis framework and methodology

4.1 Developing thematic contexts for the content analysis (CA) framework

The context of analysis is vitally important. In this section the first aspect of the context is explained from the theory to develop the deductive framework. The other contexts for the analysis include the ethnographic perspective of the researcher, as well as the inductive categories derived in the second level analysis (dealt with in the second section of Part II i.e. in what follows). The first theoretical context is deduced from the broad literature review in Part I, by the thematic categories of investigation. The wider ethnographic experience which adds to the context of analysis cannot necessarily be fully captured in words, but the process is revealed. More detailed attention to it is left for the analysis section where it becomes relevant as a basis for secondary interpretation of the data and the findings through the skill of the researcher. The ethnographic experience is augmented throughout the data analysis process: the researcher was able to make notes during the interview sessions, but then also made additional notes in the analysis process in 'reliving' the experience. These notes add a 'retrospective' dimension to the ethnographic experience, and are complementary to the other two contexts. They add value to the interpretation of results.

The three investigative themes are discussed briefly below, before being arranged in a deductive framework for coding categories. These coding categories correlate to sub-propositions or indicators for the sub-research questions, thus providing the deductive analysis framework, which will be used to *analyse* the text or data derived from the interviews as transcriptions. Gathering evidence for or insights into these propositions and problem statements contributes to gaining insights into the primary problem statement:

Socio-economic pathways need to shift course, and there is little understanding of how SCIs within ISs may enable or hamper a shift towards a more sustainable direction.

As well as into the primary research question:

How do socio-cognitive institutions within RIS constrain or enable pathways to sustainability transitions at different structural and scale levels?

Stemming from this, a discussion about the three investigative themes, which relate to the three sub-research questions and aims in context of the literature review, is turned to below.

4.2 Theme I: Analysing the capacity of regional innovation systems

As already discussed in the literature, one can readily distinguish between ISs or RISs as conceptual phenomena or policy frameworks and their actual functional capacity. In other words, much of the theory describes ISs as assumed networks of components and their inter-relationships. In this dissertation these are described as elements and mechanisms – but the quality and strength of actual ties in reality is what is most important. In actuality, ISs are not perfect and often don't function optimally as systems; they can always be improved. In the literature, therefore, frameworks have been developed to assess these imperfections against potential strengths and weaknesses of ISs and particularly of RISs. This theory, whilst linking to the literature review provides additional depth to the framework for analysis in answering the research questions.

4.2.1 Capacity, and characterizing weak ISs and 'lock-in'

One of the central notions in the RIS literature concerns the apparent trend in the understanding of innovation processes as only being effective if organized in terms of a non-linear and interdependent problem-solving process, diffused in a favourable interactive system. Although this 'interactive system' is not context specific, and acts more like a network, and is not necessarily confined to any spatial regularities (Doloreux 2002), the roles of proximities and spatial influences do need to be considered in the failure of ISs. That is why the RIS approach is seen as the appropriate theoretical lens to assess IS capacities.

It is clear that the RIS concept takes the notion of territory and proximity more seriously than the NIS concept first explained in the review of the literature above. The additional factors of territory, proximity and embeddedness of innovation processes are the predominant features of RISs that distinguish them from NISs. The MLP discussed above also highlights the RIS understanding that networks are certainly not confined to specific boundaries or spatial territories and can extend in many instances up to the global level.

However, when trying to understand the functioning, strength and weaknesses of ISs, the regional territory as a sub-national domain becomes an important unit of analysis. According to a strict reading of the literature as suggested by Cooke & Morgan (1998) there are only a few 'fully-functional' RISs globally. These include Baden-Württemburg in Germany, Emilia-

Romagna in Italy, and Silicon Valley in the USA. A perspective also exists at the other extreme that all regions (with urban centres) have an IS of sorts, even though they may be weak. The subsequent question is how does one know a RIS when one sees one? (David Doloreux & Parto 2004).

In this case it may be useful to return to the notion of operational vs. conceptual RISs, the ideal of course being to improve or strengthen them through governance and policy interventions. A first step is to understand what the weaknesses, gaps or failures in the system are. In Part I, Cooke *et al.* (1997) are reported as distinguishing between two extreme ideal types of ISs, where the one system shows strong characteristics and the other weak characteristics as prominence of RIS elements. This is followed by Doloreux and Parto's (2004) explanation of five different ideal types. What both reveal is the many different characteristics and perspectives on RISs, highlighting the difficulty in establishing an exact approach or methodology to analyse their strengths or weaknesses. The complication between the control or authority over a region by either national or sub-national authorities and other jurisdictions should also be considered in each case.

To investigate the case studies it will be necessary to summarize the main points and characteristics of weak ISs. For analytical purposes in this dissertation, these weak characteristics will refer to the RIS as the unit of analysis, even though many aspects would also be true of an NIS. Ultimately a better understanding of weaknesses in the RIS as system failures, dysfunction and deficiencies provides an opportunity to improve them through policy and governance assistance (Asheim *et al.* 2011).

The aim of this sub-section then is to highlight the different characteristics, types and elements that may make a RIS weak or fail. Generally speaking and through following deductive logic, it would make sense to speak of weak RISs as having low levels of innovative capacity because of a low connectedness between their constitutive elements resulting in ‘system failures’ (Oltra & Saint Jean 2009). Elements in the system include: firms or clusters; institutions; knowledge and innovation infrastructures; and innovation policy. In reality, each RIS case is distinct, and the level of innovative capacity and strength of the system depend on the influence, strength and presence of these elements as well as how well they function both independently and through interactions.

Klein Woolthuis *et al.* (2005) suggest a 'systems failure framework', which provides a useful and clear distinction between *actors* (more as organizations and elements) and *rules* (more as the outcome of interactions between the elements). If essential organizations are lacking it may cause system failures as 'missing actors'. Rule failure for example may be when industrial policy is too strict, or cultures too risk averse (institutional failure) or when networks between firms are not functional (network failure). Below is a brief summary of this system failures framework in Table 7. It will be used to assist in analysing the two case studies to determine the strengths of each as capacities and capabilities.

Table 7 – Systems failure framework

Innovation System Failure	***Characteristics***
Infrastructural Failures	**Lack of physical infrastructures supporting innovation** - e.g. ICT, broadband, roads **Lack of Science and Technology infrastructure** - e.g. Science Parks, R&D infrastructure, testing and patent facilities,
Institutional Failures	**Hard Institutional Failures** – the formal institutional mechanisms that may hinder innovation, e.g. technical standards, labour laws, risk management rules, legal system, contracts, industrial policy etc.[26] **Soft Institutional Failures** – failures in the socio-political sphere, where society shares rules, norms, culture and values. These may include risk aversion, unwillingness to share resources and knowledge, lack of an entrepreneurial culture, mistrust, and divergent social norms and values.
Interaction Failures [Lock-in]	**The links, interactions and cooperative relationships** between the actors in the RIS, e.g. between government and public knowledge institutes, or between firms and consultants, may be poor. Failures may occur due to *weak* (too little interaction) or *strong network failures* (too much interaction). *Strong network failure* results in a situation of lock-in where actors are guided by other actors in the 'wrong' direction and consequently fail to seek or to supply each other with the required knowledge (which may be external to the network). *Myopia* may also occur as a result of too much internal orientation, or 'group think'.

[26] In South Africa for example this would include the tender process as stipulated by the Municipal Finance Management Act (MFMA).

	This can result in IS failures because: …insufficient attention is paid to developments outside [the group] and firms [or actors] may be locked-into existing (technological) trajectories. Successful networks (hot spots) may well develop into unsuccessful ones (blind spots) due to ignorance of relevant developments outside. (Klein Woolthuis *et al.* 2005:614) This also conversely relates to the strength of weak ties argument already described in the above sections - suggesting that weak ties come with new information, and hence may stimulate innovation. This failure is called 'lack of weak ties'. Furthermore, strong ties may be reinforced due to political allegiances or dominant power relations resulting in failure arising from *dependence on dominant partners*. Finally weak network failure occurs when the connectivity between elements is poor, preventing fruitful cycles of learning and innovation.
Capabilities Failure	Where companies or actors simply lack the resources, capacity or capabilities to innovate or adopt new technologies. Also linked to cognitive proximity, this phenomenon has also been labelled as a 'Transition Failure' because companies lack the ability to transition to a new technology or technological paradigm. This may lead to a case of dependence or lock-in into existing technologies for the firm or cluster.

(Klein Woolthuis *et al.* 2005)

Supporting this view, Tödtling and Trippl (2005) suggest weaknesses in ISs are deficits with respect to organizations and institutions, and a lack of flows or exchange of knowledge between the different sub-sets of RIS. These are depicted in Figure 4.1, which show a distinction between knowledge production and diffusion, and knowledge application and exploitation. In the *first* instance deficits, weaknesses and failures may take place between these sub-systems. This results in failure, due to underdeveloped organizational and institutional set-up. In some instances weakness may also occur due to coordination failures between multiple levels of governance. This may range from inadequate maintenance of international networks, to regional and national policy failures. *Secondly*, when it comes to interaction within sub-systems, failures and blockages can also occur within the networks and between the ties of the elements. Two types of problems can be distinguished here, the first is characterized by weak ties, which translates into poor inter-organizational communication and cooperation – of the kind necessary for effective innovation performance of regions. The

second relates to ties that are too strong, which results in a situation of lock-in where no new information enters the system, with the result that the recipients of the networks struggle to innovate. In conjunction with these two points, a region requires continuous stimulation of external networks which often is a prerequisite source of new knowledge and information (Tödtling & Trippl 2005).

More specifically a weak IS can be characterized by the following aspects relating to poor interaction between the elements or sub-systems of a RIS:

a) **Firm weakness** – A group of firms that neither contribute to regional innovative capacity, nor form a cluster or collaborate between themselves or higher education institutions, or established firms suffering from institutional lock-in that stifles innovation. **Institutional weakness and rigidity** – This refers to two things: (a) weak ties between organizations, and a thin organizational culture of cooperation and innovation, often related to a weak institutional **framework or 'thin' institutions supporting** innovation; and (b) Strong institutions with old habits, norms, rules and laws which are difficult to change thus not allowing innovation to take place or be implemented.

b) **Weak knowledge and innovation infrastructure** – Weak innovative capacity may result from a lack of knowledge and innovation infrastructure, or poor 'functional' proximity due to lack of transport or ICT infrastructure.

c) **Weak policy and governance** – No specific regional innovation policy, innovation intermediaries or development organizations that could assist in strengthening the innovative capacity

(Derived from a summary of Cooke *et al.* 1997 and Doloreux & Parto 2004).

From a more spatial perspective Tödtling and Trippl (2005) also distinguish between three different types of 'problem' regions – peripheral regions, old industrial regions and metropolitan regions. Peripheral regions may suffer from 'organizational thinness' because there is a lack of agglomeration, R&D, and organizational support, and the critical mass for cluster benefits is not reached. Old industrial regions often face a situation of lock-in as mature industries dominate and overspecialize in innovation trajectories making them vulnerable to rapid changes in the market or to loss in competitive advantage. *Metropolitan areas* are usually seen as the most innovative regions, with high levels of innovative capacity

due to the proximity of universities, R&D activities, clustering and networking in the urban space. However, this is not always the case and in some instances there is a high degree of fragmentation of firms and networks which leads to low levels of interactive learning and innovation (Tödtling & Trippl 2005).

Finally, it is important to emphasise that too much or two little proximity can result in or characterize weak innovation systems. Of particular interest is the concept of rigid social, institutional, organizational and cognitive interactions which may result in lock-ins.

4.3 Theme II - SCIs as a determining factor for sustainability-oriented innovation systems (SoIS)

The literature review reveals that economic activities, production systems and innovation activities (i.e. as an IS) are embedded within institutions and are intricately linked. The institutions, may be formal or informal, and in any case the form, quality and constitution of institutions differs at different structural and scale levels.

Taking into account this notion of different levels and scales of embeddedness and make-up of institutions, Figure 4.1 helps summarize the discussions about the various elements and mechanisms of RIS. This diagram shows the connection between the NIS and a RIS, and how a RIS is embedded in the regional socio-economic, cultural and institutional setting. It is undeniable that institutions both shape and are shaped by economic systems, especially at lower levels of aggregation like the regional level. While in Todling and Trippl's (2005) view there is a separation between two sub-systems of the RIS – between knowledge application/ exploitation, and knowledge generation/diffusion. For effective functioning of the RIS, the elements and mechanisms need to interact unhindered. This also ensures effective functioning between the two sub-systems of knowledge generation and knowledge application.

Exchange between mechanisms and elements in RIS does not always happen smoothly in reality – which may be a direct result of differing socio-cognitive institutions at different structural levels. The flows of information and the quality of exchanges determine the strengths or weaknesses of the system of innovation. As a basic rule, the more networked or connected a RIS is between elements and mechanisms the more functional it is. The more flows of knowledge and information pass through it, the higher its level of functionality, or potential functionality. The point to be made here is that the functionality of an IS, does not *per se* determine its direction. Innovation outputs are influenced by the institutions (both

formal and informal) within which they are embedded. Socio-cognitive institutions make up a special kind of institution that exists formally as knowledge generation, transfer and learning within society, and informally as culture, norms and values. Socio-cognitive institutions, as recognized in the literature, are integral to innovation processes.

As expressed in the introduction, a key question that is not explicitly dealt with in the literature remains. What is it that would, could or does shift these socio-cognitive institutions in a sustainability direction? More so, do these sustainability-oriented socio-cognitive paradigms have an influence on the direction of IS? It is proposed in this dissertation that SCIs play a major role, but their influence and impact differ at different structural and scale levels.

Below is a depiction of the RIS sub-components, and the structure of a typical RIS. This model shows clearly that the two sub-components of RIS are embedded within wider socio-economic and cultural settings. This model not only summarizes the discussion in the literature review above, but it also provides a clue as to why or why not SCIs may be oriented towards sustainability. The problem here is that the model itself is devoid of any reference to the socio-ecological domains within which innovation and economic systems are in fact also embedded.

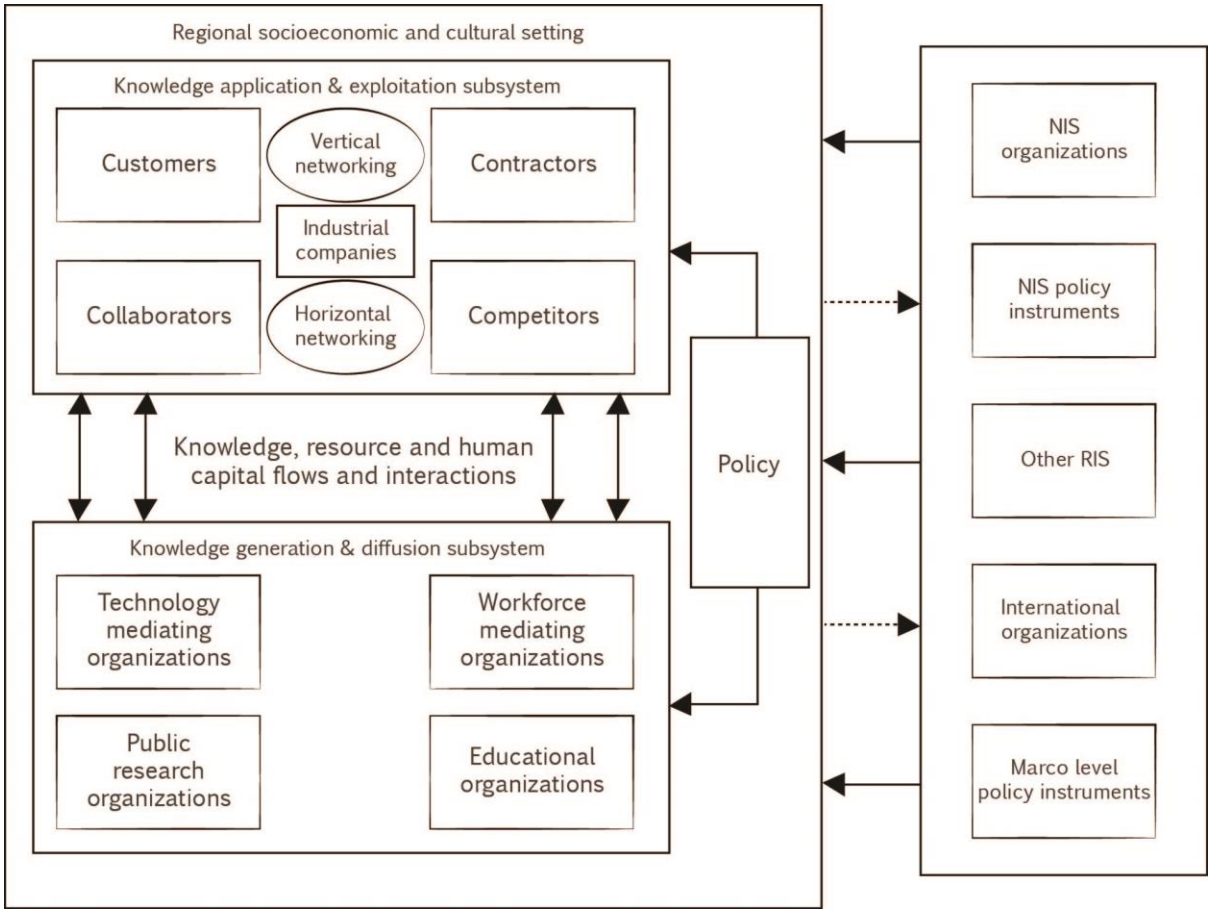

Figure 4.1 – A model of a regional innovation system components, sub-components and interactions (Todling & Trippl 2005)

It is apparent that multiple perspectives in the form and function of RISs exist. The notions of proximity also provide a better understanding of the complexities of RISs. The many descriptions of RISs stem from multiple cases and contexts. Although RIS as a concept and construct stems from the NIS concept, it is theoretically richer in describing the regional context, and the notion of proximities, networks and social learning. This academic project of RIS, already began some time ago, but it remains fragmented and opposed (Uyarra 2009).

There has been ample work done on RISs to provide a degree of certainty in terms of a framework for analysis of different case studies. Also, it is logical that the region as unit of analysis provides a different result from the nation. This leads to inherent differences in the theories of RIS and NIS. Differences between the RIS cases, also show the complexity of developing one uniform theory about RIS. The multiple perspectives inherent in the literature, whilst useful in one sense for the purposes of comparison, also reflect the heterogeneity of cases. Developing a solid theory of RIS further will require continued

recognition of the patterns that characterize successes or failures of the RIS. Similarly, a continued focus on how socio-cognitive paradigms of actors and institutions in ISs may shed light on how to drive ISs towards sustainability. From a logical point of view, sustainability-oriented innovation systems are innovation systems that are host to actors and socio-cognitive institutions supporting of sustainability. From a SCI perspective, this may be in the form of formalized knowledge and research stemming from universities, or less formal attitudes, values and norms promoting innovations that are sustainability-oriented.

The notion that ISs are not only embedded within institutional frameworks, but also wider economic systems that influence the direction of innovation is more clearly expressed in the NIS literature. This is an important point, because ultimately the ability to transition socio-economic systems toward sustainability will be determined by the direction of innovation systems. In turn this theme seeks to investigate to what extent this is derived from, or as a result of alternative *formal* (through knowledge production) and *informal* (through societal thinking and perceptions) socio-cognitive institutions.

This is a complex investigation, and it is also recognized upfront, that socio-cognitive institutions (SCI) are not the only influence. For example, it is explicitly recognized that smaller groups of actors within ISs may be opposed as SCIs to other groups and their SCIs. This may debilitate or constrain outcomes, even though the socio-cognitive paradigm of groups may be favourable towards a sustainability-orientation. Even more-so, wider non-human influences such as the market, or shocks and events have an influence on the ISs that may be opposed at the group level. References to socio-cognitive institutions therefore imply more than the group level, and suggest that the intentions for sustainability are aligned to the outcomes of the system making it sustainability-oriented.

The third theme of investigation, which is turned to below suggests that socio-cognitive institutional lock-ins are related to and influenced by proximities. These are ‘structures’ existing between RISs actors as institutions, and can be assessed as social, cognitive, organizational, institutional and geographic proximity, ‘closeness’ or ‘distance’. It is for this reason that the notion of a multi-level perspective of ISs makes it possible both to understand innovation dynamics better, as well as to recognise the potential for governance towards more desirable or sustainable innovation trajectories.

An important point to be made is that institutions developed and embedded within ISs, are fallible. At the same time, they are not short lived. They constitute the ethos and affect the entire functioning of the IS. As explained in the introduction, they can be deeply cultural and extremely stubborn, or easily influenced loose fads and trends. In these terms, the difference between conventional ISs and sustainability-oriented innovation systems is often more tangible than one might imagine, especially when outcomes are measured in terms of their sustainability impacts on the socio-economy. In analysis of the case studies, this kind of evidence may be clearly visible. However, the socio-cognitive institutional history that influenced the trajectories of the RIS to produce these 'sustainable outcomes' is of most interest. The critical point to be made prior to the investigation is that 'conventional' ISs are different from sustainability-oriented ISs, and are inclined to produce innovations that perpetuate unsustainable development.

4.3.1 Critique of conventional innovation systems

Rogers (1983) in his prominent work, 'Diffusion of Innovation' noticed that there was very little research focus on the consequences or effects of innovation in society or on the economy. A follow up study by Svieby *et al.* (2012) came to the same conclusion, and showed that the trend to assume that innovation is by definition a societal good remains common. Through their review of the literature and use of various search engines they show the topic of '*unintended and undesirable consequences of innovation*' to be seriously neglected by the research community. This suggests that in many ways society has a biased view of 'innovation' as always positive, whereas in many instances it can be quite negative and destructive.

Whilst the Svieby *et al.* (2012) deals with mainstream literature on innovation and extends the question to all forms of undesirable and unintended consequences, they suggest very little work focuses on sustainable development. Climate change is mentioned in only one article, which looks at the rebound effects of reducing energy consumption through new innovations (Herring & Roy 2007, cited in Svieby *et al.* 2012). This shows that at present there is a lack of literature that looks at 'unsustainable innovation' as well as the effects that innovation systems may have on their wider societal and ecological environments.

In the context of a world that is trying to achieve sustainability and inclusiveness it is surprising that such a focus on ISs for sustainability is not already well established. There is some work on ISs for 'inclusiveness' coming from the NIS literature on developing countries

(Bjorn Johnson & Andersen 2012; Lundvall, Joseph, Vang, & Chaminade 2009) but very little work on the effects ISs have on sustainability. In fact there is very little critique of conventional ISs. They remain in many ways rooted in a mainstream conception of innovation as competitiveness for economic growth, idealistically referred to as 'innovation-bias' in the literature (Gripenberg *et al.* 2012). The concept of sustainability-oriented innovation systems (SoIS) is aimed at countering this, and is particularly relevant for STs.

4.3.2 Sustainability-oriented innovation systems (SoIS)

Sustainability-oriented innovation systems (SoIS), or sustainable innovation systems, is an emerging concept that has been mentioned in the work of a few authors and practitioners to date. Rennkamp and Stamm (2009) from the German Development Institute and Montalvo (2008) from the Dutch TNO both mention in their papers the need for SoIS systems. The general consensus is that there is a need for SoIS systems that are distinct from 'normal' or traditional concepts of ISs. The primary difference is that mainstream ISs focus on promoting innovations for the purpose of competitiveness and economic growth, rather than sustainable development.

Conventional ISs are defined more narrowly than SoISs in the sense that they are aligned to mainstream economic thinking and measurements of innovations. For example the OECD definitions of innovation usually refer to measurements of innovations in terms of R&D transfers and patents. ISs in the traditional sense may be summed up as the components and functions leading to innovations (patents) and their diffusion (uptake and sales in markets). See (Blankley *et al.* 2006; OECD 2013b) for examples of this.

Although there is no formal definition or theory of sustainability-oriented innovations, they can differ in several respects. The first is that the measurement of innovations is not as narrowly defined and includes a variety of important categories of novelty that cannot be neatly measured within mainstream economic thinking or the market. These include positive externalities, environmental benefits or fostering inclusiveness in socio-economies. The strict, traditional definition of an innovation is that it reaches the market, whereas innovations for sustainability cannot necessarily be measured directly in those terms (Blankley *et al.* 2006; Björn Johnson & Lundvall 2000; von Malmborg 2007). Although sustainable innovations in most cases may reach the market anyhow, a SoIS should take into account the wider effects on the environment within which it operates so as to achieve the production and diffusion of

innovations in a sustainable way. It should therefore consider the degree of improved value to the economy and society whilst considering the environment.

Sustainability-oriented innovations no doubt include technologies such as eco-innovations and clean-technologies. UNEP (2014) has recently developed a global eco-innovation program to promote changing the focus of business towards sustainability through innovative practices. This is achieved through developing new strategies for the company, business model innovation and improving or innovating operations. Eco-innovation has also recently become a focus for academia, and regional development (Cooke 2011; Dearing 2000; Hellstrom 2007; Rennings 2000; Speirs *et al.* 2008). Many sustainable innovations or innovations that are designed for efficiency such as eco-innovations and clean technologies do reach the market and are conventionally measureable innovations. However, the more social aspects of 'inclusiveness' of innovation are difficult to measure and require different insights and different methodologies to monitor (Berdou 2014; OECD 2013a; World Bank 2012). Sustainability transitions similarly require new insights into the way in which social processes and progress can be measured within ISs.

4.4 Theme III - Multi-level structures and multi-scalar approaches in ISs and STs

In reality ISs, like social systems, are complex phenomena. They do not have any finite boundaries, but, rather like social groups, they can be understood by their network affiliations or frequency of ties to actors or organizations in a group. Although it lies beyond the scope of this dissertation, Social Network Analysis or SNA, is a useful method to map graphically the density of social networks through the frequency, nature and quality of ties between actors in groups, or in society (Cross, Borgatti, & Parker 2002). Understanding social networks within RIS, their densities and qualities, illuminates both their level of embeddedness and the qualities of ties (See for example Cross *et al.* 2002; Bodin & Crona 2009; Pryke 2010; Butts 2009). SNA is not used as a method of analysis, but can be referred to in a broad sense when discussing social networks within RIS. In the analysis of these cases, the primary focus will be on the qualities of the ties, which are inferred throughout. However, the analysis goes deeper than SNA, as the socio-cognitive institutions are understood abductively through speech, attitude, position of the interviewee in relation to social movements and historical progress.

RISs are dynamic and evolving, and constantly change in terms of interactions between the elements, and the mechanisms that make up their dynamics. These dynamics call for rich interpretations. That is the primary reason why a qualitative assessment makes for a better understanding of the characteristics of any RIS. It allows for capturing complexities and the contextual nuances that are specific to each RIS.

In relation to the investigative theme, it is important to highlight that networks or dynamics of ISs exist on multiple levels and are different on each level. It is not only the nature of the ties or their quality that differ at different structural levels, but also potentially their frequency. The RIS literature deals with these differences, in the language of proximities. It highlights the role of 'local social interaction' which gives rise to different qualities in the RIS networks. These qualities, which are possibly less formal, include tacit knowledge and kinship ties and trust that may not be found in wider or more aggregated structural networks. It is strongly argued in the RIS literature that these qualities are associated with spatial proximity (Boschma 2005; Asheim *et al.* 2011). This understanding of the relation between spatial proximities (not neglecting other proximities) and structural formation of socio-cognitive institutions (as expressed in structuration theory, and ST theory) is of particular interest.

It is proposed by the researcher, that spatial proximity plays a large role in the formation (and re-formation) of socio-cognitive paradigms (of individuals and groups) and institutions (of spatially based social groups or communities). The results of this investigation would have particular bearing on the theory of STs, and more specifically the MLP, which is non-scalar or spatial in its understanding of socio-technical structures. The MLP neglects the intricate dynamics, of how alternative socio-cognitive institutions may be formed because of spatial proximities, or influences. However, the more recent GOST literature, as reviewed in Part I reveals a promising avenue to considering spatial aspects within the ST debate.

Qualities of ties between actors in the RIS, are closely related to socio-cognitive institutional formation. However, SCI are proposed as a special kind of institution. They are assumed also to be affected by the other forms of proximity, like spatial proximities are (as discussed in the literature review). In other words, socio-cognitive paradigms of actors are influenced heavily by the various forms of proximity and mostly by spatial proximity when it comes to 'informal' socio-cognitive institutions; and less so when it comes to 'formal' socio-cognitive institutions. This may be through both formalized and informal knowledge exchange, shared

identities, local realities, local leadership, culture etc. Based on the above explanations, therefore, the key assumptions for this investigative theme are the following:

a) The micro-level can be understood as actors, groups and networks that are tightly bound (or have strong ties) and share closer socio-cognitive proximities.

b) Spatial proximities play an important role in influencing and shaping these socio-cognitive proximities within defined territories. These groups holding specific cognitive characteristics, become institutionalized and 'accepted' in society when extended into more social networks – becoming socio-cognitive institutions. They are at first informally shaped, eventually becoming formalized when 'taken-up' into the RIS structure and wider institutions.

c) SCIs at the micro- structural level, may extend, through influence and social learning, the SCIs at meso and macro levels within a RIS.

d) Alternatively, changing ISs dynamics towards sustainability within a socio-spatial context may also lead to changes on wider socio-spatial scales.

e) Both these SCI influences, whether bottom up or top down or both simultaneously, may influence, extend structurally, or expand socio-spatially to influence the wider RIS. The primary assumption is that SCIs begin at a point, as a group, either socio-spatially or structurally, and may extend to influence the wider RIS.

f) The inter-connectedness between socio-spatial and socio-structural scales and levels can be clarified and understood in a proximities framework – and, as proposed, from a socio-cognitive proximities perspective.

Socio-cognitive proximities are defined for this dissertation as the distance or closeness of specific socio-cognitive institutions. What this means is further qualified in the discussion section, post-analysis. Its relevance to socio-economic transitions is critical. Distant SCIs within an RIS, would no doubt manifest as differing visions, goals or directions that the RIS takes, thereby determining the direction of development. On the other hand, close SCIs between various groups, or even between different SCIs within the RIS, may signal not only conflict, but competing ideals as to the appropriate socio-economic direction of the RIS. The effects of this are not yet known or explored, but the subject will be returned to in the case study analysis in Part III, and discussed in Part IV.

4.4.1 An institutional and evolutionary economics perspective on the multi-level dynamics

Although institutional and evolutionary economic perspectives are both present, and the terms are often used interchangeably in RIS literature, Boschma and Frenken (2006) distinguishes between these approaches. He is not alone. Malerba (2005) points out that while institutions and institutional settings are a strong focus and central to ISs in the way in which they influence actors and embeddedness, evolutionary approaches take networks and sectors as key units of analysis. This applies also to the ways in which new technologies and sectors emerge simultaneously creating new institutions. The co-evolution of economic, institutional and technological forces shapes knowledge sharing processes, as well as industrial dynamics and supporting structures (Uyarra 2009).

While the MLP and transitions theory takes into account these micro-meso-macro dynamics, they have a stronger focus on the socio-technical rather than the wider concept of the socio-economic. This provides an important additional dimension to ST theory. In the analysis framework, these linkages between technology and society are made. However, there is a considerable difference between the MLP theoretical conceptualization of the multi-level (micro, meso, macro) as socio-technical structurations and the more socio-economic and institutional economics conceptualisations of Dopfer and Potts (2009) and Potts (2007).

In ST theory the focus is on socio-technical structurations (as units of analysis) as opposed to the looser combinations of technical, socio-economic, and socio-institutional conceptions as in the institutional economics view. Furthermore, the MLP in transitions theory has an explicit focus on understanding transition of socio-technical systems towards greater sustainability during a time-period (Grin, Rotmans, & Schot 2010). Often it is through technological innovations, that new socio-cognitive institutions are formed, and *vice versa*.[b] The influence of the different forms of proximity (with an emphasis on the spatial) as discussed in RIS literature will of course be important in understanding in more detail the processes of shaping of institutions between the micro-meso-macro levels as a co-evolutionary process. The evolutionary analytical framework as suggested by Dopfer & Potts (2009) could aid in understanding these formations of new institutions within ISs. Especially important is the formation of the meso-level (social structure) as a process of combinations of micro level actors and their cognitive preferences through association or identification with new technologies or social movements.

What will be of particular interest in analysing the results of the case studies in Part III is how socio-ecological and socio-economic concerns have influenced and shaped new socio-cognitive institutions, and *vice versa*. It is assumed that this mostly takes place within the spatially-based social movements and technology choices of actors at the micro-level and local scale. But these micro levels and scales certainly cannot avoid influence, especially SCI influence on and by broader meso- and macro levels and the regional and national scale of the economy. New SCIs for SoIS, are assumed to lead to socio-economic transitions within territories, and through spatial association with innovation systems in a region, also to socio-technical transitions. A better understanding not only of co-evolutionary processes, but also of spatial-institutional processes in the shaping of institutions as micro- (less formal) and meso- (more formal) structures supporting innovation for sustainability should be a primary focus in transitions theory. Bringing these theoretical keystones of influence on institutional formation from a structural, multi-level and proximity perspective into an analysis framework is a good start. Applying such a framework to two divergent case studies takes the effort further in ways aligned with the primary purpose of this dissertation. The analysis framework below is described in the terms of the above discussions.

4.5 Theme I - Propositions and research sub-questions

Table 8 – Research sub-questions associated with Theme I

RQs associated with investigative Theme I – Capacity of regional innovation systems
Associated propositions:
P Sub-1a:
Strong and functional RISs have a greater capacity to enable socio-economic transitions to sustainability.
P Sub-1b:
Weak RISs, have less capacity to produce and diffuse innovations, and hence enable socio-economic transitions to sustainability.
Research Sub-Questions 1: RQ Sub-1a: ***Do strong and functional RISs have a greater capacity to enable socio-economic transitions to sustainability?*** Alternatively RQ Sub-1b: ***Do weak RISs have less capacity to enable socio-economic transitions to sustainability?***

4.6 Theme II – Propositions and research sub-questions

Table 9 Research sub-questions associated with Theme II

RQs for Theme II – Socio-cognitive institutions and direction of RIS (i.e. SoIS)
Associated sub- propositions 2:
P Sub-2a: ***Socio-cognitive institutions are a primary enabling factor for determining the direction of innovation within RIS as a system.***
P Sub-2b: ***Socio-cognitive institutions are a primary constraining factor for determining the direction of innovation within RIS as a system.***
Research sub-questions 2: RQ-Sub 2a:
How do SCIs within RISs have an influence on the direction and qualities of innovation outputs in the regional/local economy?
Alternatively RQ-sub 2b:
To what extent are socio-cognitive institutions a determining factor for sustainability-oriented innovation systems resulting in pathways for socio-economic transitions?

4.7 Theme III - Propositions and research sub-questions

Table 10. Research sub-questions associated with Theme III

RQ's for investigative Theme III - Multi-level structures and multi-scalar analysis in SCI formation
Associated sub-proposition:
P Sub-3: ***Socio-cognitive institutions exist and are shaped differently by various forms of proximities on different structural and scale levels.***
Research sub-question 3:
RQ Sub-3: ***How do socio-cognitive institutions exist and how are they shaped by various forms of proximities on different structural and scale levels?***

4.8 Conclusion for the three investigative themes and sub-research questions

The section above lays the foundation, and links the literature review in Part I, and the investigation, i.e. the case studies. The sub-research questions become this primary link, as answering them requires further categories of investigation based on the wider body of literature already discussed. These categories are shaped into the analytical framework, and explicitly derived from the literature – and become the deductive analytic framework for the content analysis. Further categories, are created once engagement with the cases and the data

begins, which completes the analytical framework, allowing for new insights to be gained into the literature.

4.9 Developing the framework for content analysis

First it is necessary to provide summary tables of the literature, in context of the various investigative themes. For the full breakdown of the various stages of development of the analysis framework please view this in Appendix C1. This appendix contains a systematic breakdown of the literatures, into various codes for each investigative theme included in the following tables: *RIS characteristics & coding categories; RIS Elements; RIS Mechanisms; RIS and SIS Industry Characteristics; Functions of IS; RIS Strengths, weaknesses and capabilities; Literary deductive framework and sub-research questions; Literary deductive framework and sub-research questions; Literary deductive framework and sub-research questions; Deductive coding Matrix for the Content Analysis for Themes 1-3.*

These summaries will be useful in developing a coherent reference and guide back to the literature in both the content analysis (CA) and in the reflections on the theory in the findings section.

4.9.1 Developing a deductive analytic framework for CA from the literature

To answer the research questions, it is necessary to provide a summary of the literature on the characteristics, elements, mechanisms and functioning of RISs. These topics were extensively dealt with in Part I. They are transformed into deductive coding categories, and sub-categories for the analysis. The various primary and sub-codes are associated to one of the three investigative themes.

From these summaries it will be possible to clearly develop several coding categories for investigating the case studies in relation to the literature as deductive content analysis of the data. These coding categories can then be applied to the data, and also linked back to the wider body of literature, and respective authors for analysis. Each investigative theme will require different emphases in terms of the use of coding categories derived from the literature. The coding categories used in the analysis are picked according to their relevance in assisting to prove or disprove the sub-propositions. These sets of codes are described in the Appendix C1, in tables, and their configuration for each sub-research question are clearly marked in this in separate tables. The codes are depicted in black, and are at this stage only associated to the literary component. It is important to note that this only forms the first part

of the development of the framework that will be used in the CA. These literary coding categories are divided into primary and sub-codes and need to be organized according to the three investigative themes, and associated to each sub-research question.

4.9.2 Brief conclusion and discussion of the analysis framework

In answering the research questions (RQs), it should again be noted that the framework's application to the primary data only provides part of the answers. Some of the sub-research questions may be answered in relation to secondary data. Another important aspect is the secondary level analysis as ethnographic observations of the researcher: providing known facts about the case studies serves as a form of validation. CA is extremely useful in abductively inferring meanings from the primary data or interview text to give answers and insights into the primary and sub-research questions.

As mentioned throughout this dissertation, RIS is used as the primary theoretical lens for investigation. However, to answer the research questions fully, the findings need to be assessed in relation to the ST literature post-analysis. This forms part of the reflection on and discussion of the findings in Part IV, following the findings of the CA and ethnographic analysis in Part III. The ST literature does not form part of the coding categories in this study, and therefore does not need to be summarized in the same way as the RIS literature has been. The reason was to highlight the differences between 'conventional' ISs and SoIS, where the latter could become a valuable theoretical approach to achieving both socio-technical and socio-economic transition to sustainability. How socio-cognitive institutions within RISs may enable or constrain ISs from becoming sustainability-oriented or not may be the key.

4.10 Introduction to research methods and methodologies

A variety of methods were used in the research design of this dissertation. These included a case study approach, which was imperative for framing the research as two separate case studies. Although elements of the cases are comparable, a comparative case study analysis was not envisaged. Rather the aim was to provide a comparison of the contexts within which the studies were conducted to inform the final arguments in answering the research question. No doubt elements of the case studies are comparable, but the contexts are so different that it would have been futile to design the study along more rigid comparative lines. Furthermore, the point of conducting a free-flowing investigation would have been hampered, possibly distorting the result. The notion of 'free flowing' arises from the researcher approaching the research as a journey from the onset.

The South African case was suited to a transdisciplinary study. The Austrian case, by contrast, was retrospective, and only suitable for a less intensive ethnography and included a series of interviews. The methodology of both studies was a mixed methods approach. This applied to the design of the research, including the data collection and the analysis. In both studies, the data collection included ethnographic approaches, but more markedly in the South African case. In both Austria and South Africa it included 'themed' or 'loosely guided' interviews to validate the claims of the researcher. For the South African case, however, additional TD processes were adopted and recorded, including focus groups, workshops, events and active participation in meetings. These set of methods, methodologies and a brief introduction to them are now discussed.

4.10.1 The case study method

The case study method formed part of the core research methodology for this study for the following reasons: i. relevance to the 'objects' (technical) and 'subjects' (culture) of study; ii. the options a case study provides in terms of data collection; iii. the relevance and suitability of providing the framework for merging methodological processes and a mixed method research design. These aspects will be explored in the description of the intended use of the case study method below.

Silverman and Marvasti (2008:164) identify three different types of case studies: i. the intrinsic case study ii. the instrumental case study and iii. the collective case study. The first type (intrinsic) is usually an 'out of the ordinary case' and there is only an attempt to describe the case, which is inevitably 'theoretically laden'. The second type (instrumental) is examined mainly to provide insight into an issue or to revise a generalization. The third type (collective) involves investigating multiple cases of the same phenomenon. For this study two instrumental case studies were undertaken: The RIS of Styria, in Austria and the RIS of Stellenbosch and the wider Western Cape, in South Africa.

Case study methods were used as the methodological framework to gain new insights, and thus revise generalizations of key aspects of RIS and ST theory. Silverman *et al.* (2008) contend that most case study reports are ultimately based on some concept(s) that are developed as a result of doing the studies. The case study methodology is used to provide boundaries for the study. It draws on different viewpoints of various authorities on case studies (Yin 2003; Silverman & Marvasti 2008; Babbie & Mouton 2001).

Silverman *et al.* (2008) and Yin (2003) both suggest one of the primary reasons for doing a case study and or qualitative research is to produce 'explanations which are generalizable in some way, or which have a wider resonance'; or more specifically, in Yin's (2003) terms, it is for an agenda of generating new theory and concepts from analytic generalizations.

Babbie and Mouton (2001) see case study methodologies as traditionally used in a disciplinary environment like business studies, jurisprudence, and social work. However, this methodology is now more widespread and acceptable across disciplines. For example, it has been used as the primary method for Transdisciplinary (TD) studies at the ETH, Zurich TD Lab. Case Studies have thus been shown to be a useful method for conducting TD research (Scholz *et al.* 2006; Scholz & Stauffacher 2010). Earlier criticism of case studies suggested them to be 'less than scientific'. However, in the last two decades they have been established as 'extremely useful' for establishing theoretical understandings. Yin (2003) defines a case study as an 'intensive investigation of a single unit [of study]'. This may even refer to a community or culture (Babbie & Mouton 2001) and is thus appropriate to study regional and local innovation systems, especially when geographic or physical boundaries are known.

4.10.2 Units of analysis and boundaries of the case studies

If Stellenbosch, Western Cape, and Graz, Styria are considered as case studies, they should be defined as spatial territories of regional innovation systems that have either embarked on socio-economic transitions pathways, or have the vision and potential for STs. Case studies, according to Yin (2003), can be comprised of 'several units of analysis' in one study. These are known as embedded case studies. For that reason, the sampling of case studies is also important, as in qualitative research. Babbie and Mouton (2001) identify and present an array of different 'units of analysis' ranging from the single person to a whole nation. The South African case study is embedded, because it involves two distinct 'units of analysis' conducted as two simultaneous research processes, of the same case. They are simply divided as two levels, the local level and the regional level. The RIS of the Western Cape was the case boundary, and represented one level; and the 'Transforming Technopark' as the local level, formed part of the same case study.

The units of analysis were defined spatially by the functional city-regions of Graz[27], Stellenbosch and greater Cape Town. It is appropriate to have several units of analysis in one

[27] It also included several smaller neighbouring towns or localities: Leoben, Gleisdorf, Weitz)

case study for comparison with another case study with similar 'units of analysis.' This study focussed on the individual level, the community level, the social group level, the institutional level and the study of events, roles and relationships of specific actors, institutions and organizations in the Austrian and South African locales. These aspects make up the elements and mechanisms of the RIS as the general unit of analysis of the case. Although an important 'unit of analysis' for the content analysis, the text data does not qualify as a 'case study unit' in its own right. Thus the specific units of analysis, for the content analysis, become the data and text derived through interviews and interactions in the case studies. The case study methodology incorporates the content analysis approach to data collection and data analysis. This is explained in greater detail further down.

4.10.3 Transdisciplinary case study (South African case)

Transdisciplinarity (TD) could be described as more than a philosophy, as it includes a methodological approach to case study research. A key principle of TD is that the object or subject of study cannot be conceived of adequately through a mono-disciplinary lens, because the problem scenario in sustainability research is often complex or 'wicked' and any substantial understanding or research of it requires an extension beyond the scope of one discipline. A proper understanding of complex sustainability issues may even require going beyond the disciplines to the language of the practitioner, societal actors and the descriptors involved in the problem scenario. This is primarily what TD research represents, a valuation of the language, understandings, skills, viewpoints and interpretation of actors beyond the scientific disciplines. In the more formal 'methodological' approach developed by the Swiss, TD case study research is about the co-development and co-research of complex problems in coming to a joint solution to these problems with society (Scholz & Stauffacher 2010; Scholz *et al.* 2006). This often involves two teams, an academic team and a practitioner team, which together make up the transdisciplinary team. This formal style of TD research was deemed impossible for the current project, given the limited resources and time constraints of one researcher. However, the principles of TD were adhered to in the form of a 'consultative' style TD approach (Mobjörk 2010), in the Technopark and Stellenbosch case. There was no possibility of adopting this approach in the retrospective case of Austria, whereas the South African case was about 'tracking' a contemporary co-development of a vision and strategy called 'Transforming Technopark'. This meant that the researcher was aware of co-defining and co-developing (envisioning) a solution to the issue of 'Transforming Technopark' with non-academic actors. However, in both cases, following the consultative approach, these

understandings were in the end described from the perspective of the researcher, strongly influenced by those 'consulted'. The researcher also took ethnographic methodology into consideration when he was involved in the Stellenbosch case as an 'active participant.' To a lesser extent this applied also in the Austrian case. The ethnographic approach is aligned to the content analysis (CA), which allows for a degree of objectivity and distance in systematically analysing the data that was produced including the researcher's own contribution through a rigid analysis framework. This provided interesting emic, or 'insider perspectives' in the findings.

For research on (regional) innovation systems, the TD approach is recognized in this dissertation as important for the following reasons: the first is that IS, by definition, is precisely about recognizing the value and contribution of various forms of knowledge that lie beyond the boundaries of the university and R&D; secondly, problems associated with knowledge transfer from R&D and Universities are often precisely because of a lack of a platform for producing a 'common language' where the scientific worlds, the commercial world and governance challenges meet.

Over and above this, IS and ST literature are already inter-disciplinary, meaning that they are derived from integration of various scientific disciplines, including economic theory, sustainability science, innovation studies, systems thinking, regional studies and more generally sociology, psychology and institutional theory. Another important reason for using a TD approach, or at least conducting the research in awareness of it, is in 'deciding the purpose' for generating knowledge itself, and thus the intended theoretical outcome for the research. This is captured in the following statement in the Charter of Transdisciplinarity: 'life on earth is seriously threatened by the triumph of techno-science that obeys only the terrible logic of efficacy for efficacy's sake' (Nicolescu 2002: 147).

Another particularly important reason for adopting a TD approach in addition to an inter-disciplinary approach is precisely the ability of the TD method to transcend the various disciplines and encounter 'non-traditional' forms of knowledge. This forms an important aspect of this research study in which there is a dedicated effort to capture different forms of knowledge over and above disciplinary knowledge. This is especially important when reflecting on the status of the socio-cognitive paradigms of actors and institutions of groups of actors. TD research forms an important argument for an improved methodology to generate knowledge for sustainability-oriented ISs.

There is an ethical dimension attached to the manner in which such research is conducted. Ethical guidelines for researchers, as spelt out in the 'Sage Handbook of Fieldwork,' edited by Hobbs & Wright (2006), will be adhered to. Hobbs & Wright will also guide my intended field studies, and together with the 'Handbook of Ethnography' (Atkinson *et al.* 2001), will guide me through the traditional approaches to ethnographic research and 'participant observation'.

4.10.4 Descriptive methods and 'capturing the narratives'

A simple descriptive method has been employed during the case study to describe the various components or aspects of regional innovation systems. Often this requires more 'technical' language or the language of the descriptor. Again this is common practice in content analysis, and in some cases requires the exact words or quotations from of the descriptor: 'in vivo' coding descriptions. A descriptive method will also be used to describe the various technical or socio-technical systems or processes, inherent in and specific to the case studies. In some instances, as suggested, the actual wording of the descriptor may be used, or it may be necessary to use the language of the descriptor, for example, an 'engineer' who describes the process of 'waste collection' and disposal, or training for 'solar technology'. Understanding this language and the context it is spoken in and then interpreting it may also be necessary from time to time: this generally requires the researcher to make sure the meaning is not changed.

Another powerful method, for conveying a certain meaning or understanding that is fundamental to qualitative research is the narrative (Silverman & Marvasti 2008). In the analysis of the case studies, and more specifically each interview, a narrative or 'story' is revealed. Understanding the interviews as narrative, in the context of a wider narrative was important to ensure reliability. That understanding informed the context of each interview. Each interviewee formed part of the collective narrative. The collective narrative was then associated and checked against the TD and ethnographic experience of the researcher. In addition, the narrative was checked and validated through external sources and secondary data. In most cases, the narrative was confirmed through tangible and explicitly available evidence. For example, the existence of certain clusters is common knowledge, and the existence of companies that are referred to by those telling the story can be checked online.

4.10.5 An ethnographic approach to the case studies

Ethnographic research is very well suited to gathering qualitative data – as the researcher embeds him/herself in the object of study. In this case, then, the study is necessarily subjective in capturing the extant socio-cognitive institutions and culture associated with development paradigms in the Stellenbosch and Styrian cases. The ethnographic approach can add an additional dimension to content analysis, especially when the researcher is involved in the data collection process. It also coincides with a TD approach, as the researcher embedded himself in the social network of actors in the Stellenbosch case, and to some extent in the Styrian case.

Using an ethnographic approach, the researcher is able to participate and simultaneously observe. He may act as a 'human recording device' while acknowledging influence in the process, via a reflexive method, which requires some self-awareness and discipline from the researcher. In some instances, however, there will be the opportunity for a more 'distant' observation as well. This may take the form of documentation via sound recordings or a photo album, or video recordings in which the researcher is involved. This allows the researcher to listen to or view his or her own experience during the research process (Atkinson *et al.* 2001). This method was used in both cases.

However, the intention of ethnographic research is to gain access to emic or insider perspectives, in this case the insider perspectives of those actors involved in the regional innovation systems and local innovation systems of the Western Cape and Stellenbosch, Styria province and Graz. These actors included academics, researchers, government officials, industry and business people, intermediary organizations, NGO's, civil organizations, and entrepreneurs. This broad approach 'enables the ethnographer to see interrelationships at the margins and multiple layers of meaning that might be overlooked or ignored in a more focused and narrow approach (Lewis-Beck 2004).

Finally, the general justification for using an ethnographic approach can be summarized in the words of Geertz, and in referring to ethnographic approaches as 'being there' says the following:

> What a proper ethnographer ought properly to be doing is going out to places, coming back with information about how people live [or work], and making that information available to the professional community in practical form
>
> (Geertz 1989)

4.10.6 Document and archival analysis

Various documents, policies, transcripts, public notices, information, advertisements and other forms of evidence for the research may also serve as secondary data in the content analysis of case studies. CA also becomes a systematic tool for analysing these official documents and reports as data and secondary evidence for the case study analysis where required in the South African case.

The codes, developed in the 'coding category' can also be applied to the secondary data in searching out specific 'phrases' or 'descriptions'. These may provide clues or contain one or another typology or symbolic representation of a specific 'ontology', culture or understanding of a socio-cognitive paradigm. There may even be evidence of underlying forces embedded in certain policy documents or reports. There is no specified historical time limit. Rather, defining the relevance of any particular document will be at the discretion of the researcher, who attempted to discover and 'unearth' such documents via contact with certain actors during the case study period. The focus on document and policy analysis is not the main research component, but is complementary.

4.11 The process of 'content analysis' (CA) used in this study

In qualitative data analysis, there are three major approaches: interpretative, social anthropological, and collaborative social research methods. While these approaches are distinct, they often overlap in the actual methodological approach. *Interpretative approaches* allow for human actions or activities to be interpreted as text. Text represents a symbolic meaning of real world events, and thus can inform a researcher from relevant textual records. This may be in the form of observational data, interviews, interventions and so forth. How this data is analysed depends on the methodological or philosophical approach of the research or what they are trying to achieve. In one instance the text may be 'left intact' so as to pick out the essence of meanings or interpretations. Another approach would be a more rigid analysis, which organises the data to uncover patterns of meaning. It is, however, difficult to draw a line between these two approaches in content analysis as the 'essence' of meaning is often contextual in the texts. Words are present in sentences, and sentences are present in the text as different contextualizations. It is therefore important to be clear about how one is using such a level of analysis in unlocking the meaning in qualitative data analysis (Silverman & Marvasti 2008; Hsieh & Shannon 2014).

The *social anthropological approach* is similar to an ethnography already described above. Here the researcher conducts fieldwork or case studies to collect data, and is often embedded in and amongst stakeholders. This allows for a 'special' interpretation of the data, as it provides the researcher with a more accurate understanding of how the 'research population' understand their worlds. Analysis of the data collected may then employ the interpretative approach. Often researchers using this technique, as is done to different degrees in both case studies, will begin analysis from a theoretical framework or departure point.

Finally, the *collaborative research approach*, such as action research, is intended to derive data so as to aid a specific process, solve a problem or gain insights for action. Again the approaches to both data collection and data analysis may be similar to the two approaches above (Schutt 2011; Krippendorff 2004; Neuendorf 2002).

In this dissertation, all three approaches are relevant, albeit to differing degrees in the two case studies. In the Stellenbosch case, the purpose of the research is most aligned with the collaborative research approach – which seeks to gather information and insights to inform real-world actions. In the Styrian case, the researcher was less concerned with the outcomes of the research, and how this might influence future actions. Rather, the research was more about gaining insights through engaging with stakeholders, primarily deriving data from interviews. Hence the interpretative approach is most relevant in the Styrian case, although elements of the social anthropological approach are important both in deriving the data, and in understanding the data context in the analysis.

In more procedural terms, the research follows these steps:

- Data from the case studies are collected and made into texts (through interview transcriptions). A mixed methodology between the interpretative, anthropological and collaborative approaches to the data collection and analysis is applied in each case.
- Codes are analytically developed (deductively) as a first step to analysis of the text data.
- Codes are transformed into categories (in this case the analytical framework).
- Additional categories are developed (inductively) through additional focused reading of the texts.

- Patterns and meanings are found in the individual texts (i.e. interviews) and across texts (i.e. all interviews and groups), these meanings are sorted and categorized in relation to the theoretical framework (so as to *analyse* the data).
- The categorized forms of data are relayed back to the theoretical framework and the theory in general to derive answers to the RQs and new insights into the theory.

4.11.1 Rationale for using content analysis in this study

Qualitative CA analysis is most useful for *'examining ideological mind-sets, themes, topics, symbols while grounding such examinations to the data'* (Berg 2001). Krippendorf (2004:47) lists multiple uses for content analysis, the most relevant of which are to *analyse 'attributions, social relationships, public behaviours and institutional realities'*. CA is regarded as the most suitable methodological approach to analysing the research themes and research questions in this dissertation – which expressly deals with all aspects of analysis described above.

The primary reason for using CA in this study is to ensure uniformity and a degree of objectivity in the analysis. The researcher was intimately involved in the data collection process in both studies, and thus sought a method that would allow for some retrospective objectivity in the analysis of that data. CA allows for this, by developing a rigid methodology and framework in assessing the text against pre-determined propositions or indicators derived from existing theory as a deductive approach. Furthermore, without CA, the large amount of text that the researcher has to analyse would make it difficult to get a sense of the overarching themes and arguments present in the text. The human mind can only handle 'so much' complexity at a given time. With the aid of a computer program this task is much simplified. The systematic cataloguing technique provided for in CA software solves this problem and makes the data analysis process more structured and objective. Finally, depending on the finer approaches in the analysis of the content, CA specifically allows for interpreting the text for hidden messages, and latent meanings. It is particularly useful for assessing the psychological or social attitudes of respondents. It has a rich history of use in the psychoanalytical sciences (Krippendorff 2004) and is similarly appropriate for identifying socio-cognitive paradigms of actors, groups and institutions through analysis in this study. This is important in the context of the analysis, where the researcher looks for clues as to how socio-cognitive institutions are formed or shaped by proximity effects, which are not apparent to the interviewees. This is called the abductive approach and is specific to CA. Abductive inference is about moving from specifics in the texts to specifics in the analysis framework,

correlating indirectly to answers to the research questions. They are not direct answers, because it is often not the face-value of the texts that is important, but the latent meanings in the context of the case studies that have to be brought to light.

The analysis becomes more transparent and can be validated through assessment of the context of analysis which is made explicit by the researcher. The logical inferences that are made from the interpreted meanings in the text follow a step-by-step procedure in coming to answers to the research questions (Neuendorf 2002; Krippendorff 2004). Although human interpretation and the skill of the researcher does play a fundamental role, as in most qualitative studies, the process of analysis is made explicit, and should be clear. CA also recognizes that analysing texts without a framework can be hazardous when relying solely on the memory of the researcher. Computer aided software does not replace human interpretation of meanings, but allows for keeping track in a systematic fashion, also improving the reliability, objectivity[28] and validity of the study. It is simply a tool that improves accuracy and provides results in a way that otherwise would not be possible, or would be extremely tedious. Over and above this, it remains important for the researcher to ensure that his or her interpretation remains explicit – especially post analysis – when the findings need to be interpreted from his or her ethnographic and transdisciplinary experience.

4.11.2 Using computer aided software vs. manual assessments

Human interpretation, through the knowledge and skill of the researcher of complex data in a qualitative study, is paramount. However, computer software can be used alongside it to guide the researcher, and order a wide set of meanings, arguments and findings. This is especially helpful in large volumes of texts where it is very difficult or impossible for the researcher to keep track. The computer software should be seen as a tool for cataloguing the connections made by the researcher from the text, and allowing him or her to systematically keep track of the analysis process. This allows for a faster, more rigorous, systematic and scientific process to get to the answers to the RQs. Just as a calculator may assist in speeding up the calculation of a set of selected numbers, it is still the selection of numbers to be calculated that is important. Human interpretation and thought processes cannot be replaced by computers. For all the assistance that the computer provides, substantial manual

[28] No research study can be fully objective, as the perspective of the researcher always remains present. Yet objectivity here refers to the looser understanding that the researcher should at least be aware of his or her subjectivity, and thus should maintain some distance from the interpretation. CA, due to its insistence on a rigid framework for analysis, provides such a uniform distance. The interpretation of the researcher will always be there.

interpretation is still required (Kondracki *et al.* 2002; Krippendorff 2004; Elo & Kyngas 2008). There are many different computer-aided analysis programmes available for both qualitative and quantitative analysis of different forms of data, such as text, sound recordings, pictures and videos. After an in-depth review of these different tools, MaxQDA was chosen as the most appropriate software. It rated highly in independent reviews of the different softwares available across a range of criteria. Some of the selection criteria were 'how complex an analysis can it perform?'; 'Is the code base or dictionary transparent?'; 'Is there an established user base?', 'Does it operate on Windows and is it user-friendly?' (Lowe 2010).

4.12 Ethnographic content analysis methodology & analysis process

Content Analysis (CA) can be defined as:

> …a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use. As a technique, content analysis involves specialized procedures. It is learnable and divorceable from the personal authority of the researcher. As a research technique, content analysis provides new insights, increases a researcher's understanding of particular phenomena, or informs practical actions. Content analysis is a scientific tool.
>
> (Krippendorff 2004:18)

CA serves as a technique to investigate symbolic meaning in texts. Here texts are not limited to 'writing' but can be expanded to other forms of communication, and should always be interpreted in context. Expanded definitions include: *'*taking content to be inherent in the text; content to the property of a source of a text, and; content to emerge in the process of a researcher analysing a text relative to a particular context*'* (Krippendorff 2004:19). The process of CA, is about coding raw messages found in the text into coherent and organized forms, that allow for easy identification, indexing or retrieval of content relevant to the RQs (Kondracki, Wellman, & Amundson 2002).

Neuendorf, defines CA more simply as, *'*the systematic, objective, quantitative analysis of message characteristics (2002).*'* However, the omission of the qualitative aspect is apparent and explicit in her understanding of CA. She leaves qualitative analysis to techniques such as narrative, discourse, normative, critical, structural or semiotic and conversation analyses. However, qualitative analysis has been used convincingly to analyse more 'latent' or inferred meanings found in the communication of the text (Kondracki *et al.* 2002). The position taken in this dissertation, suggests that the qualitative aspects are inherent in content analysis and

cannot be escaped. Otherwise CA amounts to a 'counting game' as suggested by Krippendorff (2004). For this reason his theoretical and analytical approach is used as the most appropriate. This does not mean to say that there don't remain important insights and considerations in other approaches referred to.

The most important feature of CA, is that it is systematic, to ensure reliability and validity in the process of analysing the data. Results should be replicable in terms of clearly stating a procedure of rules, and a framework for the analysis (as developed in the above section), the aim of which is to avoid human tendencies to read texts in such a way that they conveniently support preconceived notions or to selectively adopt meanings. Although it should be clearly recognized that a qualitative investigation always remains subjective, as the analyst cannot escape his or her own 'hermeneutic cycle' or cultural and social conditioning (Krippendorff 2004). It is therefore impossible to be purely objective – rather the aim is for the researcher to be clear about his or her position in ways that make for reliability and validity. The latter two aspects boil down to the procedure or process of analysis: i.e. can this be repeated in a calculated way and can the results be measured? If so, then the reliability and validity of the analysis is sound (Elo & Kyngas 2008; Gerbic & Stacey 2005; Neuendorf 2002).

Ethnographic CA is an approach to CA that

> …opposes the sequential nature of traditional content analysis, suggesting instead that analysts be flexible in taking into account new concepts that emerge during their involvement with texts [or the creation of the texts in interviews and case studies]. (Krippendorff 2004:21)

The background has been described above, and ethnography will form an important part of the methodological approach in both case studies. However, ethnography will be more significant in the Stellenbosch case study as the researcher has been embedded in the case over a longer period (i.e. several years in Stellenbosch, as opposed to one year in Styria). A fundamental characteristic of an ethnographic approach to CA is that researchers are free to comment and reflect on their involvement in the process of data analysis and data collection. It allows room for the analyst, especially in the case of being involved in the generation of data through interviews, to use his or her experience as an additional lens for interpreting the texts. If this were not allowed, the texts would not be as rich in meaning, and might be interpreted differently. Here it is evident that CA becomes more complex than an objective scientific approach. The subjectivity and lived-experience of the researcher becomes an intricate basis for analysis that is powerful when made explicit. The narrative of the

researcher's own lived experience becomes an additional lens (forming part of the CA context) through which to interpret the texts. From this perspective the analyst is also allowed to develop a reflexive context and flexible analytical construct, known also as a constrained or unconstrained categorization matrix or analytical construct. Constrained only allows for data that strictly fit the matrix of analysis, 'testing categories, concepts, models or hypotheses' (Elo & Kyngas 2008:112). The complexity involved in this approach, requires a clear methodology of analysis, which should be clearly stated so as to be understood by external readers.

As explained above, the approach in this dissertation involves both constrained (fixed framework derived from the literature and RQs) and unconstrained (inductive categories) matrices of analysis. The unconstrained approach allows for different categories created within its bounds, following inductive logic. From this perspective new categories can be added to the existing categories of search, making the study simultaneously both deductive and inductive. It is important to conduct the deductive analysis first (in a constrained framework) and thereafter the inductive approach can be used as a separate analysis of the same texts (in an unconstrained framework). Again, being explicit about this process is important.

The approach described above of first conducting a deductive constrained analysis, followed by an inductive unconstrained analysis, formed part of the methodological approach in this study. Coupled to the ethnographic lens of interpretation, which again will be used more explicitly in the second phase of unconstrained inductive analysis, that describes the complete method of analysis, the most appropriate for the analysis of the cases in this dissertation. A deductive analysis process is first designed from the literature, and tested. Thereafter, additional categories are added following an inductive approach to analysing the data. While a relatively rigid framework of analysis or analytical construct is prepared from knowledge about the literature, the inductive approach is also considered in finding new insights within and between the categories in a secondary analysis. This latter inductive approach allows for theoretical development as suggested by Krippendorff (2004). The final framework of analysis (including both deductive and inductive approaches), will thus only be revealed during the analysis process – and more importantly will be significantly different for each case. What is useful is that the deductive element remains the same, allowing for a degree of comparison between the cases.

However, CA is primarily about engaging with the text and its subsequent meaning to the analyst. The meanings and concepts derived from the text (i.e. content) are dependent on the aims of the researcher, and his or her approach to analysing the text. This allows analysts to differentiate themselves from 'ordinary' readers. An example is how psychoanalysts may be required to interpret dialogue between themselves and the patient in a way that is expressly analytical and different from that of the patient. In a similar way the content analyst is able to interpret meaning according to the aims of the research. This however, does importantly require a certain skill or prior knowledge from the researcher. It is for this reason that computer aided analysis, still requires the humanistic element of the analyst. Otherwise CA remains a counting game, without the ability to interpret meanings in the text. This is made clear by Krippendorff (2004) suggesting texts are contextual, in the sense that they are relative to context, discourses and different purposes. It is again up to the experience of the researcher to be able to make these contexts clear when analysing the data. For example, a political analyst will read a budget speech differently from an economic analyst and come to different emphases about its meaning, often in the context of wider discourses known to the analyst.

It is therefore paramount that the analyst makes clear the context of analysis. In this case it has been provided already from a literary point of view, and further revealed generally in the description of each case in Part III. Only by making the context explicit can the validity, reliability and replicability of the analysis be reasonable. If CA could be reduced to one core aim, it would be about analysing the text in such a way as to draw inferences to the context of analysis:

> For the content analyst, the systematic reading of a body of texts narrows the range of possible inferences concerning unobserved facts, intentions, mental states, effects, prejudices, planned actions, and antecedent or consequent conditions. Content analysts infer answers to particular research questions from their texts. Their inferences are merely more systematic, explicitly informed, and (ideally) verifiable than what ordinary readers do with texts.
>
> (Krippendorff 2004).

To summarize, CA analysis is both a methodological approach and a method of analysis. It is a methodology in the sense that it provides a framework for approaching the research design, and a method in terms of the approach towards systematic analysis. CA, is however, limited in its ability to interpret meaning, and therefore it was absolutely necessary to use ethnography to assist in developing rich findings.

The methodology of analysis using CA is thus: deductive through developing a framework of analysis derived from the literature; inductive as a secondary unconstrained analysis; ethnographic in the sense that the context of analysis employs insights of the lived experience of the researcher. Ultimately the final analysis is abductive, as it is the meanings of the text that correlate to categories and indicators derived from the context (theory/lived experience) inferring answers to the RQs. Below more detail is given about the unique characteristics of CA as an approach to analysis and specifically why this approach is appropriate for the research in this dissertation.

In the figure below, the CA process is described graphically, from the world of texts, to the many worlds of 'others' analysis.

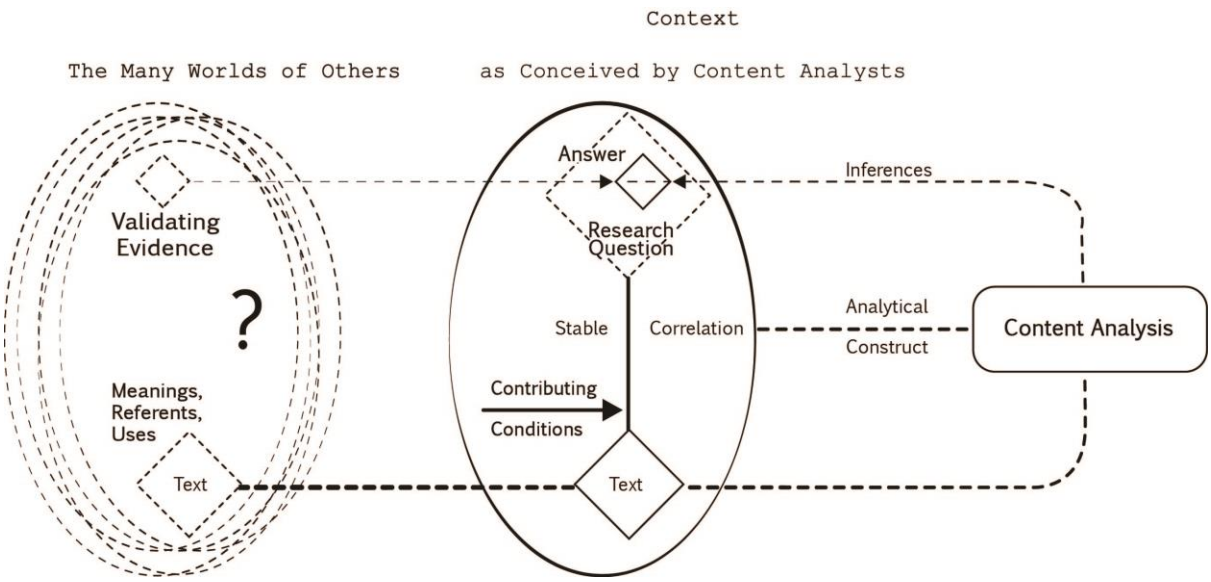

Figure 4.2 – A graphic description of the process of content analysis (Krippendorff 2004)

4.13 Summarizing the research and analysis processes

The cases have been discussed briefly in context of CA analysis. Now it is necessary to give a brief overview of the units of analysis and units of data collection employed in this dissertation. This sub-section ends off with a step-by-step description of the analysis process, followed by an overall summary of the research methodology and design of the research and conclusion.

4.13.1 Selecting units of analysis/ units of 'data collection' in CA

It is sometimes useful to distinguish units of analysis from units of data collection. A unit of analysis is the object or unit that is to be studied. Units of data collection, although often the

same, can be different (Neuendorf 2002). Here the units of data collection are interviews and focus groups, whereas the units of analysis are wider and include the context within which the interviews are conducted i.e. the case studies. Due to the lived experience of the researcher in the case studies, wider knowledge about the units of analysis can be included, as well as secondary data and knowledge about the case studies from other sources.

As already described above, three units of analysis are used in the study. The generalized units constitute the physical and networked space of the case studies (i.e. the local ISs of each case). The more specific units of analysis are derived from agents who are part of the local innovation system. The specific units of analysis for CA, which are thus also the units of data collection are the texts derived from focus groups (events) as well as interviews with key actors. The finest units of analysis are the actual meanings or intentions derived from sentences and words in the texts in the context of the research process (i.e. this includes the interpretation and influence of the analyst in the research process as interviewer and TD facilitator). This approach to selecting the units of analysis for the CA is not unique to this study, and follows theoretical advice:

> Graneheim and Lundman (2004) pointed out that the most suitable unit of analysis [for CA] is whole interviews or observational protocols that are large enough to be considered as a whole and small enough to be kept in mind as a context for meaning, as a unit during the analysis process.
>
> (Elo & Kyngas 2008:109)

4.13.2 The data collection and data analysis process in Stellenbosch and Styria

As already described above, the CA process requires a clear context within which to *analyse* the data. Doing interviews allows the researcher to generate data within the boundaries of such a defined context. This is often understood and made clear by the researcher to the interviewees. The structure and defined process that CA uses to *analyse* data, also allows for designing the capturing of data as a looser arrangement. In other words instead of rigid structured interviews that only allow for a degree of margin in the answers subjects give, CA allows for loose, free flowing answers that are generally guided by the researcher. Open-ended questions, meetings and focus groups or events allow for less formality and rigidity in the answers given. This provides a richer description from the viewpoint of the research subjects and their opinions or knowledge about a subject. The open-ended approach allows for answers that may not otherwise fit the framework or intentions of the researcher had he/she chosen a rigid interview structure. These open-ended interviews were, however,

conducted according to a set of categories or prompts that allowed the research to continuously guide the conversation. Furthermore, the loose and open-ended approach to data collection would be difficult to interpret without the aid of a well-structured approach to analysis. CA analysis provides such a structure, and serves as a method or technique to ensure the data is assessed according to a firm and reliable structure (Krippendorff 2004). The CA framework developed above forms part of this structure.

The primary data is in the form of texts, derived from transcriptions of interview and focus group recordings. Additional perspectives on these texts are provided through the personal notes of the researcher, but also the ethnographic/ lived experience of the researcher. This describes the texts. It should be noted upfront, while elements of the data collection process were very similar between the cases, the different contexts of the Stellenbosch case and the Austrian case led to differences in the personal 'lived experience' of the researcher – and hence differences in the analysis. This applies to the actual contexts as well as the theoretical contexts derived from the literature review.

The primary difference between the cases is that the Stellenbosch case was a study of contemporary dynamics, whereas the Styrian case was a retrospective historical case study. In the Stellenbosch case, the researcher had spent far more time with the respondents, and knew each of them personally. Whereas in the Austrian case the researcher was seen as a 'visitor' or outsider, which provided a different lived experience for the researcher. Although this should be recognized in the data collection process, the data analysis process was the same procedurally.

Data was collected in the Stellenbosch case through means of one-on-one open-ended interviews that followed specific themes guided by the researcher. The interviews had some structure and followed the general theme of enquiry: the 'functionality' and, 'direction/vision' of the local Technopark and wider local innovation system of Stellenbosch. The open-endedness of responses allowed for rich data to be collected about opinions, attitudes and viewpoints on certain topics, as well as insights into the functionality of the local/regional IS of the Stellenbosch (innovation district) and the Western Cape. The researcher conducted each interview separately in a secure location of the interviewee's choosing, allowing the respondent to feel comfortable to answer more sensitive questions (e.g. about politics, or personal viewpoints). It was vital for the study to gain an insider or 'emic' perspective, as considerable trust had been built up with many of the respondents

through the 'Transforming Technopark' project. While the interviews provided a deep and personal perspective on the 'problem' the various events that were recorded, allowed for broader or more general insights from the public, industry, academia and the municipality. Collectively they represented a sample of the actors that make up a local innovation system. The broader community perspective, the deeper one-on-one insights, and the lived 'ethnographic' experience of the researcher allowed for a rich, deep and integrated perspective for the analysis of the data in CA. The data collection process took place over an extended period of almost two years in the Stellenbosch case. Very importantly, the lived experience of the researcher, who became programme manager of the Stellenbosch Innovation District, provides an insider's perspective for an additional period of two years after the data collection process. This experience, and subsequent real-world evidence is vital in providing links between the initial research period and the final lived experience of the researcher in the funded project – the Stellenbosch Innovation District. The funded project itself is regarded as evidence or validation of many of the claims that will be made in the findings, and the recommendations for future research. The lived experience of the researcher cannot be translated into raw data for the content analysis, however, it will form a critical ingredient in the research contextualization, interpretation and validation process.

In Austria, there was less time to develop personal relationships with the interviewees and the research was conducted over a period of one year. However, the Austrian case allowed for a degree of objectivity that was not present in the South African case (which is necessarily marked by an insider's perspective). In the Austrian case the researcher was regarded as an external observer. In most interviews, this gained an immediate trust of a different kind, as the respondents did not feel any threat in speaking freely about their perspective to an 'outsider'. This allowed for a different kind of contextual understanding in the Austrian case, over and above the literature context. It provides additional insights into the RQs from the perspective of the researcher. It is argued that this context will always be present in a research study, and this contextual difference in a way provides additional evidence for the primary research questions of the study. It is for this reason that the lived or 'ethnographic' experience of the researcher is so important both in the data collection and data analysis process.

4.13.3 A note on the design and analysis (CA) for this dissertation

Designing a CA is not always a linear or simple process; it is 'messy'. It often requires an iterative process in designing the analysis framework between the real-world context and the

literary contexts. Narrative content itself is most often non-linear, and will thus also require an iterative process in the analysis. Furthermore, it should be noted that whilst the actions of the researcher should follow a designed process (as described above) some of these actions cannot be made explicit as they are difficult to describe in words. This is regarded as a normal anomaly in the analysis process (Kondracki *et al.* 2002). For example, this dissertation emphasises the real-world context and the lived experience of the researcher as providing an additional perspective on the theoretical context which cannot be described one-hundred percent. This experience is however intricately woven into the theoretical context which makes for a richer analysis as described below:

> Indeed, literature [and knowledge] on the contexts of particular texts, another important source of knowledge of prevailing stabilities, often includes situation-specific descriptions, temporally limited "mini-theories," and highly qualified propositions, all of which could well support a content analyst's efforts.
>
> (Krippendorff 2004:347)

Finally, the use of a computer program makes the reliability of the analysis greater. It will also be important now and again to provide the raw data in response to some of the sub-research questions or primary research questions. This is the most direct form of inference or correlation between the research questions and the text and case studies.

4.14 Describing the data analysis process

Although the analysis process is revealed practically for each case in Part III below, it is useful to provide a brief overview of the process. This has already been explained indirectly, but it is summarized and made explicit here. The process was revealed primarily in the explanation of how the analytical framework was developed. It is important here to distinguish between the development of a framework and the application of that framework. This application of the CA framework forms the primary guidelines in the data analysis process, explained by the following step-by-step processes.

Table 11. - Steps taken in the preparation of data analysis process

a) The case study interviews as well as focus groups and events, which were recorded, were transcribed becoming the text data for the analysis.
b) The various interviews and data sets were categorized according to their stakeholder or 'actor' group.
c) Thereafter the interview texts were checked against the recordings to ensure accurate transcriptions.
d) The researcher's notes for each interview, where referred to, familiarize the researcher with the thinking and insights gathered at the time of the interview or during the period of research.
e) Additional notes were made about each interview, and the impression that was gained from each interview from the perspective of the researcher.

After the preparation of each body of text or data unit, the following analysis process ensued:

Table 12 – Step-by-step analysis process

a) The contexts of analysis was completed first, through conducting the deductive analysis and coding of the texts.
b) The coding of texts took place according to the deductive analytic framework, as developed above. It proved important to *analyse* the texts several times, as each theme of investigation required a different set of codes, and thus attention to each set of codes was required in individual analyses.
c) The additional contexts of analysis were added, including the new inductive categories derived from the additional insights generated from the texts, and the experience of the researcher and the additional notes made during the initial analysis process. This includes a general overview of the specific narrative generated by each data unit (or interview) or meetings, workshops and events (collection of transcribed sub-data sets).
d) It is important to recognize that the meanings of each individual data unit, as meanings in the text, were framed in context of the individual discussion in the text, but also the wider discussion of the data set or category. This also was influenced by the additional contexts of the research perspective as well as the general 'real-world' context within which the data was derived.
e) Next the inductive categories, which were derived from the entire data set as developed, were applied retrospectively again to the entire data set of each case. This ensured reliability, making sure that no inductive category was used as part of the analysis because it had not been thought of yet in the first round of analysis.
f) It was for this reason that several rounds of analysis were used, to *analyse* the data and texts: they required different focus areas each time.
g) The inputs and interpretations of each round of analysis, would be difficult to collate without the assistance of the computer programme MaxQDA – which was used very effectively. This programme allows for note taking during the research process and assigns the notes to each data segment where thoughts, comments or insights are gained.

h) The computer programme was also invaluable when analyzing the data as data sets: in other words grouping the individual responses of interviewees as government and intermediaries, academia, and business. This allowed for a cross cutting perspective of each data set, of each coding category, but also importantly of the entire data set. In addition, it allowed for an individual, group and holistic perspective for each aspect of the coding. MaxQDA also allows for a visual, and numerical representation of weighting of each coded segment and collectively. This allowed the researcher to gain deeper insights during and at the end of the analysis process. (Some of these visual components are shown in the appendix).

i) All raw codes of data were re-*analyse*d according to the coding matrix to find patterns, to give answers to the sub-research questions. Whilst this served as a process of generalization of the findings, it also allowed for specific text segments to be used as answers to the research questions.

j) The last step involved the interpretation of meanings by the researcher, relating the findings back to the deductive analysis framework and literature. The inductive categories were then woven into this explanation to reveal new insights and knowledge generated through the research process.

4.15 Establishing reliability and validity for the research findings

Reliability in the process of the CA and the study can be gained through transparency in describing the research and analysis process. In CA, this means the method of inference must be clear as a correlation between the texts, the analytical context (literature) and the answers to the research questions. This was vastly aided by MaxQDA computer software. Validity is gained in a similar manner, but also through additional validation of the findings against external evidence (Krippendorff 2004).

In this dissertation, validity can be obtained through known events in the case studies. For example, in the Austrian case, it is known and commonly observed that a transition within the socio-economic profile in the state of Styria took place. The evidence is found in (general) documentation and a website, as well as the history of an established cluster management organization, and the organizations themselves. In the South African 'Transforming Technopark' case, a vision and a strategy were co-developed and adopted and can be found in documents, or the official website of Technopark. Another external validation for the research is the new management entity that was established to drive the future vision of the park; as also the wider spin-off initiative from the research called the the Stellenbosch Innovation District which was described in the media, and experienced by multiple stakeholders in the town. - These validations serve as evidence for changes in the SCIs of

actors and elements in the RIS, or LIS, but the research also provides insights into the dynamics of that change. This will be described in the findings section.

4.16 Summary of the research design process of the study

In this summary and conclusion, reference is now made to each case study and to processes and procedures that were followed. This provides important background for Part III, where each case is analysed in detail. To summarize the methodology used, the following points sketch the design of the research and data collection process:

- The case study methodology was employed to frame the contexts of the research as two separate cases. Establishing rigid boundaries for the cases was not entirely possible, due to the nature of enquiry into social networks and institutions as complex systems inherent within RIS. The boundaries thus remain conceptual as local and regional ISs. More concrete, however, were the geographical elements which focused on the administrative regions: primarily the 'functional' city-region of Graz, and Stellenbosch in the Western Cape. The case study approach, as explained in the introduction, was useful in framing the context of data collection and the general units of analysis, as well as providing the context of analysis.
- In the Stellenbosch case, the research field-work took a consultative, transdisciplinary and ethnographic approach. The researcher was embedded in the case through engaging with various stakeholders in the project through informal meetings, formal meetings, events, focus groups and interviews.
- In the Styrian case, the researcher employed semi-structured open-ended interview questions. However, he also engaged informally through several events, conferences and networking functions to gain an additional ethnographic experience of the Styrian regional innovation system.

The methodological design employed in the case study analysis was through the following techniques and approach spelled out by content analysts:

- The primary methodology of analysis is content analysis (CA).
- Transcriptions of the interviews, and focus group (events) were made.
- The primary units of analysis are the meanings of texts in the interview transcripts.
- The general units of analysis are the case studies, particularly interpreted against the institutional and geographic context of the cases.
- Firstly, a structured, deductive, qualitative analysis of these texts is undertaken within the context of a literature analysis of innovation, innovation systems and sustainability transitions. Through this, deductive literary categories are developed according to three primary themes of investigation relating to the research questions. Sub-themes and categories or deductive indicators are then used to *analyse* the text through CA software MaxQDA.

- Secondly, an inductive analysis is conducted as an unconstrained analysis to identify additional meanings, or categories which may originate from the texts.
- Interpretations of the meanings are considered from an ethnographic emic or insider's perspective by the researcher. This comprises an additional lens on the interpretation of the texts, as well as providing additional insights into the findings of the CA, for the RQs.
- To ensure validity, references are made to real-world phenomena and events that may in principle provide evidence for claims made in the research findings.

This methodology and research design can be described in a step-by-step process, although the actual process is iterative and non-linear. This is depicted in Figure 4.3, which brings together the wider methodological procedures and methods described at the beginning of this chapter.

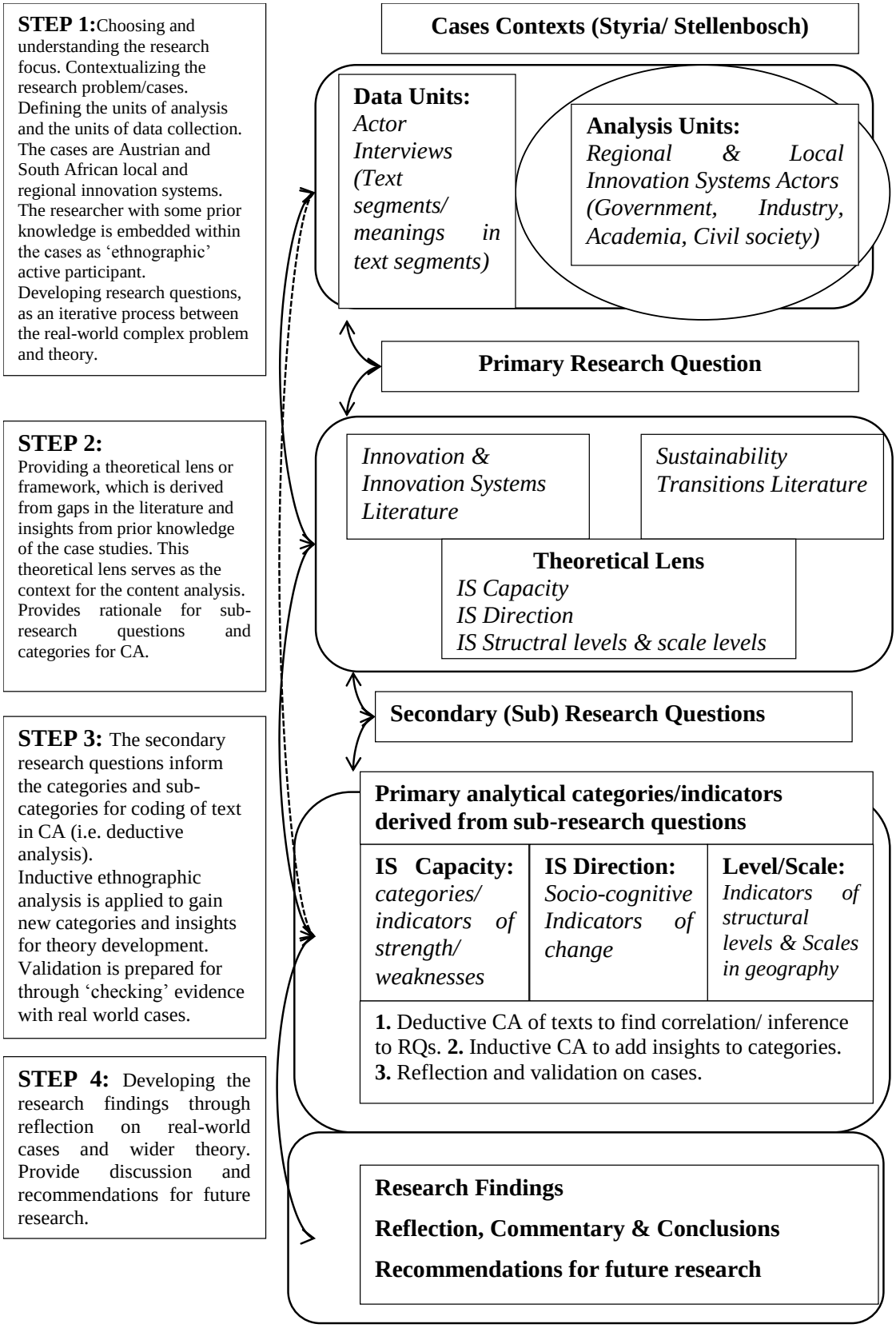

Figure 4.3 – A summary of the research design and four primary research steps

This diagram summarises the four primary research steps as a process. These concur with the steps of analysis, guided by Krippendorff's (2004) approach to methodological procedures in CA (as adapted for this study). These steps and methods contribute to explaining the methodology and research design of the qualitative content analysis in this dissertation. In Part III this design is applied in practice and described separately for the two case studies. The diagram depicts the steps followed for the entire 'research process' of the dissertation, which is explained as a four step process below:

STEP 1:

- *A statement of the epistemic issues or methodological issues that informed the analysis* – this is explained in the introduction section above. As well as in the description of the case studies below. This leads to a problem statement, as well as the research questions, which serves as the departure point for a deductive CA. Additional insights from the content in the data analysis serve as a secondary inductive analysis.

STEP 2:

- *A review of the literature*– this is dealt with in Part I of the dissertation, and is necessary to set the theoretical context for the CA. This theoretical context is narrowed down to three primary focus areas, providing the theoretical lens for the analysis. From this sub-research questions can be derived as the main categories for the CA.

STEP 3:

- *Account of the research framework/ theoretical context* – In Part II, the theoretical framework for analysis is described, and discussed critically from the literature review. This serves as the CA context for analysis. Here the categories and sub-categories for analysis are prepared/derived for correlation between the text and the RQ's. This framework's purpose is to show a clear method of inference from the meanings found in the texts, via CA, to the theoretical context for analysis.
- *A description of the research design* – This is described here, in this section Part II, from a theoretical perspective to clarify the process. These components may be alluded to again in the practical description of the research analysis process in Part III. This includes:
    - *Description of the body of texts sampled.*
    - *The data language.*

- *The units of analysis & units of data (What they preserved and ignored from the texts).*
- *The recording/coding process.*
- *The inferential techniques (Methods used in the computer programme MaxQDA, or other analytical procedures).*

STEP 4

- The CA analysis process (including organizing the data, and the analysis) include the following steps:
  - *Unitizing:* relying on unitizing schemes for the systematic distinguishing of segments of texts.
  - *Sampling:* relying on sampling plans, which allows for a representative degree of measurement in analysing the texts, and data.
  - *Recording/coding:* relying on coding instructions, links the unitizing of texts to the interpretation of coders.
  - *Reducing data to manageable representations:* relying on established statistical techniques or other methods for summarizing or simplifying data. This may include direct quotes from the texts.
  - *Abductively inferring contextual phenomena:* relying on analytical constructs or models of the chosen context as warrants. This also allows the researcher to rely on the context within which the data is *analyse*d– in this case the ethnographic experiences of the researcher, the theoretical analysis framework, and then the literature review itself.
  - *Narrating the answer to the research question:* relying on narrative traditions or discursive conventions established within the discipline of the content analyst. This allows the researcher to make the research findings comprehensible to external readers, taking into account the contexts of analysis (Krippendorff 2004: 83,84).
- *The research results (answers to the research questions)* – These will be provided as a final interpretation of the answers to the RQs. The explanation of the findings in the dissertation is given in Part III, with recommendations and commentary in Part IV.

PART III – *Chapters 5, 6 and 7*

Analysis of Case Studies and Findings

Chpt 1 – Introduction to the dissertation

Introduction - *the dissertation's argument is outlined here, defining the notion of socio-cognitive institutions as inherent in innovation systems.*

Chpt 2 – Defining and contextualizing innovation, and innovation systems

Chpt 3 – Sustainability transitions

Part I – *An extensive literature review of innovation, innovation systems and sustainability transitions. Arguments about the complementarity of the literature is made in lieu of achieving sustainability transitions via an ISs approach.*

Chpt 4 – Design, development and presentation of the content analysis framework

Part II – *The literature review is converted into a deductive content analysis framework for the case studies, with a critical discussion of it. Methodology and methods are discussed.*

Chpt 5 – Introduction to the analysis process of case studies

Chpt 6 - Case 1 – SCIs, the RIS and socio-economic transitions of Styria (1970 – 2010)

Chpt 7 - Case 2 – 'Transforming Technopark' in the Western Cape Regional Innovation System

Part III – *An introduction to the organization of data, and coding procedures are given. There are four levels of analysis of each case study. Including coding of data texts from interview transcripts, inductive interpretation resulting in new categories or findings, ethnographic interpretation by the researcher as a narrative, and finally the researcher generalizes patterns in the findings. Each case was distinct, but collectively they contribute extensively to novelties in understanding the role of socio-cognitive institutions within ISs and STs.*

Chpt 8 - Discussion of the findings in the context of STs

Part IV – *this is the culmination of reflection on the findings of the case studies back to the research questions, so as to answer them. Recommendations for future research are also given.*

Part III – Chapter 5, 6 & 7

Context in dissertation: *A brief introduction to the case study analysis process is given. The two empirical case studies form the basis for the generalization of the findings of the dissertation.*
Aims: *The aims are too report on the case studies, their analysis and provide a systematic revealing of the data according to the three investigative themes. Here a retrospective Austrian case and contemporary South African case as regional innovation systems are described, in alignment with the content analysis framework.*
Primary argument and logic: *In the Austrian case, socio-cognitive institutions for sustainability within the regional innovation system often grew from grassroots movements, and entrepreneurial action of individuals supported by strong institutions. Their functional innovation system seized new opportunities for innovation for sustainability through formalization in their regional innovation system. In the South African case, the role of collective visioning, lead to some practical programmes and projects, like 'transforming technopark' and 'SID'. These also represented, and resulted from novel socio-cognitive institutions for sustainability in the local innovation system of Stellenbosch.*

Dissertation orientation Part III

Parts I and II of this dissertation were designed to support the analysis of the case studies here in Part III. In Part IV, the findings of that analysis will be reflected back to the literature where the contribution of the research is discussed in the context of the investigative themes and propositions. Part III lays the foundation for the final part, where the findings are discussed in the context of ST literature using a RIS lens. It prepares the findings revealed through the deductive analysis framework for the final section where additional inductive findings are revealed, adding weight to the conclusion of the dissertation. Thus, the primary purpose of Part III, in the wider context of the dissertation, is to report and discuss the results of systematic use and application of the analysis framework as adapted to both Austrian (Styria) and South African (Western Cape/Stellenbosch) cases.

The two divergent cases are not investigated for direct comparative purposes. Rather the investigation is designed to ascertain the weight of the assumptions made through generalizations in theory – more specifically IS and ST theory. Both these theories have been developed predominantly in Eurocentric and developed world contexts. Testing theory in other contexts, allows for new perspectives to be gained on it. The analysis framework remains the same for both cases to permit some comparison in the final Part IV of the dissertation.

Most of the analysis work was done through coding data texts and through interpreting and generalizing results. In writing up the findings, it was important to link back to the literature when systematically answering the research sub-questions. The findings assist in highlighting expected and unexpected answers to the sub-research questions and the primary investigative themes of this research. As a reminder, the aims of the research are to investigate in general how ISs may contribute to STs, and, more specifically, whether socio-cognitive institutions within these ISs play a role, and how. Finally, the research also aims to discover whether the context of place and space matters in the development, retention and change of SCI, and how this is related to various forms of proximity, geographic contexts and social structures at macro, meso and micro levels. For ease of reference both the analysis that is conducted and the findings will be presented in terms of the three investigative themes and subsequent analysis frameworks.

5 CHAPTER 5 - Introduction to the analysis process of case studies

5.1 Rules for organizing data, categories and coding procedures

To ensure consistency in the coding the data, it is necessary to have rules for organization of the data into consistent groupings as a starting point. This prepares the data in a structured way for the various levels of analysis which are described below. Organization of the data into coherent groupings makes for consistency across the data and for the remainder of the analysis process. The process described below is designed specifically for the case studies. Procedures described in more detail include: the categorization of data; texts; the 'rules' for coding; and the levels of analysis.[29]

5.1.1 Categorization and organization of data texts

a) Interviews and their texts are categorized into different groupings or sets. These included government and intermediaries, academia and firms.

b) The deductive analysis framework was plugged into MaxQDA, and colour coded according to the three investigative themes. Sub-codes were developed under each primary code which ensured a formal structure under the coding categories. This format and structure was to remain rigid, and could not be changed. The inductive coding categories were developed for each case study during the second analysis procedure. Please see the complete coding structure as it was used in MaxQDA in Figure 4.4 below, or in Appendix D3. The actual analysis file with anonymous names of interviewees is provided in Appendix 'E-File MaxQDA Austria' for validation purposes.

5.1.2 Levels and procedures of analysis

There were four levels of analysis or independent procedures in the coding and the retrieving of texts. The process involved reading the data text, and assigning a code to specific segments. It was also possible to write notes and memos on any segment of text or meaning in the text documents. This allowed the researcher to reflect on information and responses in the text (and assisted in developing the ethnographic reflections in the analysis). The order of coding texts and retrieving text segments is the following:

[29] For the detailed expose of the analysis, please request the MaxQDA file from the researcher directly.

a) *First* the deductive analytical code framework is used to find and code segments of the text that fit each category, primary code or sub-code. This is called 'classic coding'. It was important to remain strictly disciplined at this level of analysis. This meant that the researcher had to constantly ensure that generalization of the data fitted the category, primary code and sub-codes. The computer program, MaxQDA, assisted with this process and ensured continuity in the discipline of analysis.

b) The *second* level of analysis is the inductive approach, based on the knowledge of the researcher. This is strictly guided by finding additional answers, evidence or insights for the primary and sub-research questions. These inductive codes are only created if the data represents findings that may reveal additional insights for the research questions, and they cannot be coded into the existing deductive coding matrix or framework. They are recognized as new categories by the researcher, and bring new insights into the investigation. However, although there may be some small overlaps in the 'term' or label of the code itself – it is about the intended meaning that is inferred. Here the skill and interpretation of the researcher is paramount. This also includes insights which are from the researcher's perspective important for adding value to the reflection on the ISs and ST literature. Once a new inductive code is developed, it forms part of the overall coding matrix. It was therefore necessary to go through all the text data a second time using only the inductive categories developed to ensure uniformity in the analysis. The inductive coding framework and coded segments can also be seen in Appendix D1.

c) The *third* level of analysis is about the ethnographic experience and knowledge of the researcher in being involved in the process. Here the skill of the researcher is used to create in-depth understanding and contextualization of each interview, as a narrative. This level of ethnographic analysis also contextualizes the various narratives into groups (i.e. academic, government or industry perspectives) which are important for the next level of analysis in aggregating and finding patterns in the narratives. This 'reflective' and reflexive data is created as notes and memos during the coding process. Although these notes and insights are not strictly used as data that will be coded, they become part of the analysis process. The researcher was also able to reflect on notes written during the data collection period – which were included and

assigned to each data segment in summaries in MaxQDA. These signals and reminders assist in developing the insights of the lived experience of the researcher.

d) The *fourth level* of analysis is about aggregation of the coded segments, not only within each data unit or interview. This process in fact involved re-analyzing each coded segment and creating summaries of each coded segment in accordance with the coding categories and how they related to the research questions. While each interview forms a narrative from the respondent it is also necessary to capture each group narrative. There are thus two procedures involved in this level of analysis: the first to extract the information on each code in the correct order, i.e. according to the analysis framework for each interview; the second to group this information for each category between interviews or data groups and sets. Once again, the computer program ensured consistency in this summarizing process. Although the program simplified the task, it remained tedious and laborious, requiring several in-depth readings of the data. The computer program also allowed the researcher to quickly link back to the main body of text that contextualized the passage or sentences that had been coded. This was a vital exercise to ensure accuracy in the summarizing process. Each coded segment was *analyse*d and summarized according to the investigative theme and from the ethnographic perspective of the researcher. Here the skill of the researcher was most important, but continued checking was necessary to ensure accuracy.

This level of analysis is about capturing the narrative from each grouping i.e. academics and researchers, government administrators, civil organizations and intermediary organizations (triple-helix organizations), as well as patterns across data units as a whole. Finally, and most importantly, this level of analysis also includes finding patterns between the investigative themes, coding categories, primary codes and sub-codes for the entire body of text data. This allows for a holistic perspective and a narrative aimed at providing comprehensive answers to the sub and primary research questions.

5.1.3 Analysis combinations using MaxQDA as a tool

The power of utilizing a computer aid or tool, like MaxQDA, is that it can give rapid results to specific modes or combinations of enquiry which form part of an analysis. This program is able to divide the documents or text segments and the codes into different compartments. It is therefore possible to produce multiple combinations of enquiry into the data of the texts, as well as aggregate these data sets according to specific combinations of enquiry. Appendix D1 'E-File Austria Case', provides the actual primary combinations and isolated sets of data, as lists, that allow the researcher to answer on specific aspects of enquiry. In this way it is possible to systematically *analyse* each investigative theme, and compare the differences between different social groupings (or data sets). Below is a basic pictographic reference, which highlights the number of coded segments (shown by the size of the circles, on the vertical axis), against the various document groups (on the horizontal axis – which are anonymous here and can't be seen).

Please note, the sub-codes are not shown here, nor the horizontal axis, which represent the twenty-five coded documents of anonymous interviewee transcripts. For a list of the groups please see Appendix C2.

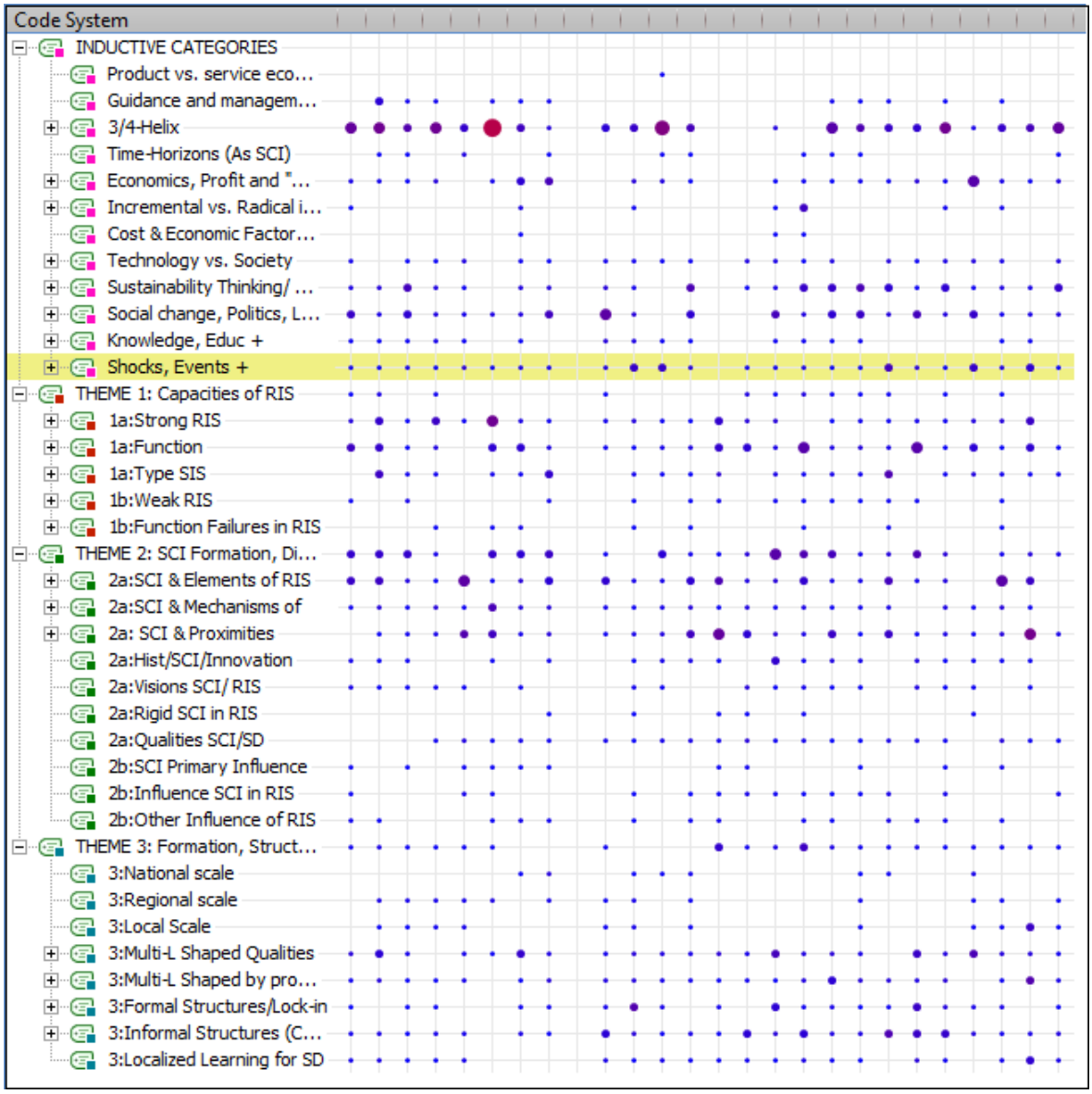

Figure 5.1 – Primary codes categories and the frequency of codes in documents

5.1.4 Summarizing, generalization and interpretation of data

This was an on-going task throughout the analysis, tackled by attaching memos to the data as it was prepared, and at each level of analysis described above. However, summarizing was also a part of the analysis process, during the inductive phase of analysis, as several new thoughts about the case were 'unlocked' in the mind of the researcher. It was important that these are captured – which was done in the summary notes associated with codes in the MaxQDA program.[30] However, although summaries of the data require interpretation from an ethnographic point of view, they are driven by the enquiries framed by the sub-research

[30] The entire process of analysis and generalization can be viewed on the 'Austria Case' e-file, and can be requested from the researcher. See reference to appendix E-File in Appendix D.

questions and investigative themes. Generalizations are important, as they form the basis for presenting the findings of each case. These generalizations involve a piecing together of all the notes, and summaries of each individual interview, each coding category and across groups and eventually all the data, with the purpose of picking out patterns, regularities and inconsistencies in the raw data so as to form a smoother and more general narrative as an answer to the research question. In many cases the raw data, as direct quotes from the respondents, forms part of this. It enhances the reliability and authenticity of the data narrative in relation to the generalized narrative interpreted by the researcher. It is also a form of validation in answering the RQ's. MaxQDA is an invaluable tool, in helping to organize the coded segments according to each of the specifications mentioned above. It allows the researcher to use extensive skill and analytical prowess to read and summarize each segment of enquiry, and therefore relatively easily piece together a narrative.

6 CHAPTER 6 - Case 1 – SCIs, the RIS and socio-economic transitions of Styria (1970 – 2010)

Styria is an interesting case, not only for its current socio-economic status as one of Europe's, if not the world's, most innovative and economically progressive regions, but also because it was known as a centre of knowledge generation as far back as during the Hapsburg empire. Together with Vienna, the current capital of Austria, and Budapest, the current capital of Hungary, Graz in Styria was regarded as one of the primary hubs of power: a capital of classical cultural practice and knowledge generation (Govt & Int G 2012).

In the state of Styria, there are five universities: Karl Franzens University in Graz, which is a classic university dating back to the Hapsburg Empire; two technical universities (Technical University of Graz and University of Leoben); a medical university and a private research university, the Johanneum. Several other smaller research institutes also exist in the region, not including the five competence centres which are hybrid university-industry research organizations.

The purpose of mentioning the region as a centre of knowledge during the Hapsburg Empire is to recognize the importance of history, not at face value as a series of events, but for its deep influence on the modern day culture and socio-economic characteristics and functions of the region. This historical culture remains embedded, not only in the values, attitudes and thinking of Austrians and Styrians as SCIs, but also in the technological fabric and architecture of their towns and cities, in their transport systems, and in their coffee shops supporting their unique Austrian culture. This culture could be described as a friendly, precise, calculated and honest mentality. While the historical Austrian culture from the Hapsburg Empire has been influenced by major events, including entering the EU and internationalization, the cultural inertia remains strong.

What is described above reflects the researcher's perspective on an experience of Austrian culture. The researcher, being an outsider, was able to reflect with some objectivity on the cultural aspects and how these link to the physical or locational infrastructural design of Styrian towns and cities making for a socially collaborative and cohesive society. This is the climate in which the research on the region's RIS took place, with a specific emphasis on understanding and experiencing the subtle nuances of culture, place and socio-cognitive

institutions. The various towns and cities is where respondents resided, firms were located or were host to key infrastructures of the RIS.

6.1 A brief overview of interviewees and data sets

The respondents were divided into three primary groupings: Government and intermediary organisations, University academics and researchers, and selected CEOs and senior managers from the Eco-world cluster. Please view the Appendix 'D4' for a more extensive description.

The first group 'Govt & Int' included government and intermediary organizations which were often linked to government through administrative support or funding. The intermediary organizations included the cluster management organizations, the regional business development agency, competence centres, regional industry associations, civil organizations, and specialized intermediary research organizations. The respondents in most cases were experts or the leadership of these organizations. These specific organizations were chosen due to their sustainability-oriented work within the Styrian RIS and were associated with Eco-world[31]. Eco-world was the departure point for identifying appropriate interviewees and respondents for the research. A snowball technique was then used to create a list of twenty-five of the most appropriate experts from government, intermediaries, academia and industry. Interviews were all conducted face to face, in the province of Styria, during the researcher's internship year at the Institute of Systems Science, Innovation and Sustainability (ISIS) between August 2012 and September 2013. Interviews were transcribed shortly after this period.

The next data set was University academics and researchers. The criteria for selecting these respondents included their current and historical knowledge about the Styrian RIS, their leadership positions in their institutions, and their affiliation to innovation or sustainability research. All interviewees in these groups had a PhD, and most were professors, senior researchers or Vice-Rectors of the universities.

The final data set or group of respondents was made up of specially selected CEO's or senior managers of firms that formed part of the Eco-world cluster. These firms were identified as pioneering firms associated with innovation champions for sustainability. They grew as entrepreneurial ventures from the 80s and 90s. One representative firm was historically part

[31] As will be described in more detail in the remainder of this chapter, 'Eco-world' was the name of a clean-technology and sustainability-oriented group of companies or cluster in the region of Styria. Its website can be visited for more information www.eco.at

of the state-owned enterprise of the 1980s, and later broke away and specialized after the decision to privatize it. All of the firms interviewed were small (fewer than 200 employees), except one, which was a medium sized enterprise having more than 200 employees. These firms were physically located within small towns on the outskirts of the city of Graz – Leoben, Gleisdorf, Weitz.

6.2 Reporting the findings of the Austrian Case

The findings of the case are reported from the researcher's retrospective and interpretive perspective. There is no attempt to report on the findings in a chronological fashion, but rather in the order that evidence is revealed in the data analysis. Emerging patterns within the analysis process form the general response, and it is these patterns and groupings of responses that provide a more generalized answer to the research questions. While the aim of the response is to ensure a generalization of the findings, the researcher also provides direct quotes from the respondents where appropriate. This may be to highlight a specific segment of information that is better conveyed as a direct 'quote'. It also ensures the authenticity of responses to the research questions.

The answers to the research sub-questions and associated sub-enquiries linked to each coding sub-category are qualitative in nature and reflect insight and understanding from both the respondent's perspective and the researcher's. The researcher's perspective is also informed by the ethnographic experience of being 'embedded' in the case study, through field notes as well as during the summary process of data analysis. Abductive inferences are used to relate what is discussed in the interviews to generalized patterns that fit the coding categories as well as reference to concepts in the literature. This systematic process of analysis outlined in Part II allows for the generalization and summary of the data findings as answers to the research sub-questions for each investigative theme (once again aided by MaxQDA). It was possible to include 'field' notes, and the ethnographic perspective of the researcher, as part of the summaries in the 'grid matrix'.[32] This was a detailed and laborious task, but enabled an important process in the analysis of the data.

Most importantly, the findings are based on a general narrative that is extracted from the data. Often this narrative is derived from respondents' reflecting on actual events that took place in Styria and Austria during the period 1970 to 2010. However, individual narratives and

[32] The data here is too extensive for the printed Appendix and can easily be viewed in the Appendix E-file MaxQDA Austria.

personal reflections on unique events that happened outside of the Styrian region, at the national and international level, also provided rich insights into the general narrative. There are considerable overlaps and affirmations between the individual narratives of respondents, and only in a couple of cases are there contradictions. These contradictions relate primarily to opinions rather than reflections on actual events.

Finally, to ensure co-ordination in dealing with the vast amount of data, the analytical framework guides the discussion, first by themes, thereafter by each primary coding category, or matrix as required (Please view the three coding matrixes in Appendix 'D' for each investigative theme as described in Part II). Coding sub-categories are discussed individually only where relevant discussions fall under primary codes. The ultimate aim is to provide systematic answers to the research sub-questions. Responses are given in most cases in order of 'Govt & Int', then 'Academia' and then 'Firm' perspectives (for both Austrian and SA cases). Reflections back to the literature are interwoven in the responses. Answers to the research sub-questions are built up within these responses, and a summary at the end of each sub-section gives clarity in answering them.

6.3 Findings Theme I – The capacities of the Styrian RIS

The primary aim of this investigative theme is to discover the various strengths and capabilities of the Styrian RIS. The findings reveal how the socio-economic structures of the Styrian region shifted from large state-owned companies to smaller, privately-owned firms during the 1980s–90s. There were several weaknesses in the RIS, especially during the time of socio-economic restructuring through the privatization of large SOEs. However, the structural change in the economy also ushered in a new era for ISs and cluster policy in the region. These shifts, together with a strong environmental movement in the 1980s contributed significantly to the modern and functional innovative capacity of the Styrian RIS. A direct link can be made between the strengths of the RIS, and the capabilities required for socio-economic transition in the region towards sustainability. These developments over the last forty years are discussed in the findings. For more detailed and technical information about the coding results associated to the findings, please visit Appendix D5 – Austria: Theme I – coded results.

6.4 Introduction and background: socio-economic transition of the Styrian regional economy

Starting with a description of the industrial sector dynamics in the Styrian region between 1970 and the 2000s helps provide perspective on the development of a sustainability-oriented Styrian RIS through time. In the content analysis (CA), the primary coding category of sectoral innovation systems (SIS), and subsequent findings are described. The more detailed findings of sector and socio-economic change towards sustainability are summarized here in a narrative.

Styria was not always an economically successful region within the Austrian economic landscape. In fact, in the past it was mired by substantial economic hardships. Many respondents referred to the crisis of the 70s. The inefficiencies of the state-owned structure of the economic sectors was pointed to as the reason for the crisis. A decision was eventually made to privatize the state-owned enterprises. These were large industrial sectors, including mining and steel, paper and pulp, and later the car manufacturing industry. The Styrian and the Austrian economy was home to large incumbents. The regional economy was classically characterised by M2 type industrial sectors and sectoral innovation systems (SIS). The break-up and privatisation of the SOE, transformed the regional economy, and with it several SIS, into M1 type of sectors (although some of the larger industry remained M2). As described in the literature, M1 type of sectors are characterised as comprised of multiple smaller and innovative firms. It was during the ’70s and ’80s that the socio-economy began to shift gradually, and in other cases rapidly towards a sustainability-orientation. The direction, however, was in part due to another influence – the environmental movement.

Not surprisingly, due to the impact heavy industry had on the environment of the region at the time there was a strong ‘backlash’ against industry. This social movement, fuelled by major national and smaller regional events, strongly influenced the direction of the socio-economy towards a sustainability orientation. These events have certainly had an influence on the prevailing SCIs of actors in the RIS over the last four decades in Styria, resulting in a shift towards sustainability in their economy. This is explained in more detail below as a summary of respondents’ perspectives.

Events that led to socio-economic transitions to sustainability – Two major, and several smaller events in the Austrian, and Styrian economic landscape, had an economic path-altering effect towards more sustainable industries. These included an anti-nuclear protest in Austria, which led to a referendum banning nuclear power at Svensendorf; and a strong environmental movement that stopped a large scale hydro-power plant at Freudenburg near Vienna (Govt & Int M 2012).

In the Styrian region, this pattern of events included: community protests to stop the building of another landfill site (Govt & Int I 2012); protests about pollution in general in the 70's and 80's including protest at the use of River Mur to drain industry waste water; and more general issues like acid rain, littering, public transport issues, CO_2 emissions and fine-particle dust from cars and industry smoke stacks in Graz (Govt & Int C & E 2012). These had a major impact on the regional SCIs driven by a common vision to halt pollution and damage to the environment. Global events, including the oil crises of the 70s and the financial crisis of 2009 also had an effect on the Styrian economic trajectories (Firm S 2012). The environmental movement in Styria had an effect on home (regional) industry and their SIS, gradually shaping the RIS towards a sustainability-orientation. Politics began to support social movements, which reacted to these external shocks, serving to reinforce the SCIs shifts towards a sustainability-orientation. This also led to legislative changes to protect the environment and fuelled new innovations. These pressures gradually shifted the industrial base of Styria into new and more sustainable directions (Govt and Int B & F 2012).

Community and social pressures to change - Many of these issues were raised by communities concerned about the environment in the '70s, a concern which was also coupled to the 'hippy' movement, the environmental concerns of which were particularly strong and continued to be influential into the '80s, placing huge pressure on government to continue changing legislation in support of clean industry. Eventually this social movement, driven by clear SCIs for sustainability in the region, infiltrated the orientation of the RIS towards sustainability in Styria.

Break-up and privatization of SOE's - Coupled to these environmental pressures, was the low competitiveness, break-up and eventual privatization of the large state-owned enterprises (SOE's) of the '70s and '80s. This had several social consequences, including unemployment and income problems in the region of Styria (Govt & Int H 2012; Academic M 2012).

The shift and breakdown of 'old industrial' complexes M2 to new emergent sectors M1, had a major effect on innovation. The socio-economic landscape of Styria was effectively reshaped by these external forces that eventually became internalized in the rise of a clean-tech and sustainability-oriented sector. These pressures, although enforcing a dedicated cluster for clean-tech (Eco-world), were cross-cutting and forced industry to become greener across the board. The three excerpts from responses which follow highlight the process:

> And maybe if you talk about progress in general, I mean, I think there was another element because a large part of our industry was owned by state control until the middle of the 80s and then they were almost bankrupt so the state was not able to manage them in an economical way. And the entire Austrian state and government did not have enough money anymore to go further on with their state owned industrial companies, so they started to split them up, they started to bring in private ownership.
>
> (Academic O 2012)

Some of these industries shifted their focus to clean-tech, both because of sustainability thinking and because of external market opportunities to solve sustainability challenges (Academic R 2012; Firm U & X 2012). This automatically led to internal regional solutions for sustainability as well for the home market, for example in reducing dependence on fossil fuels in the region:

> I mean from one resource base to the other, we always need resources, so we are, we were driven by a fossil resource base and we know, and we see that that is going down in many ways because of environmental impact, not only because of resource limitation. So what it means to me is that this will be a complete restructuring of industry in terms of science, in terms of cooperation patterns in terms of, I would say that, the structure of sector, we will have complete different sectors.
>
> (Academic Q 2012)

And externally,

> But together with the worldwide problems in environment production, motivated some of them [industries] to start their ambitious work for green and clean technologies.
>
> (Firm S 2012)

This gradual break-up of SOE's had a major effect not only on productivity but also on innovation. The large firms were sold-off piece by piece becoming smaller and more specialized, but also more innovative, stimulating diversification in the economy (Govt & Int H 2012). Because many of the staff were redeployed in different companies, the social links and trust between employees and firms continued. This was a significant social pre-condition for the clustering policy which followed (Academic Q & M 2012).

The Styrian economy was characterised by large industries in mining, steel, wood, paper and pulp, and at a later stage car manufacturing.

> Traditionally Styria was dominated by [what] you could call old fashioned industry, steel production industry in general and there was a big economic crisis at the beginning of the 80's so the economic changes were more visible in Styria than in other parts of Austria maybe, and it had certain impact on society and on the development of certain concepts, cluster policy, involving industry and education systems, other parts of the society.
>
> (Academic R 2012)

Political meddling in the running of the SOE company, coupled with bureaucratic inefficiencies, left it bankrupted – and Austrian society was unwilling to bail it out (Academic O 2012).

> So we had to change mentalities – how do you change mentalities when one of the things, well large enterprises, cannot exist anymore in this form, in this phase in the '80s the simple funds of personal costs were larger than all the income the firms had. So they went broke actually, when there's uncertain moment in time that the general manger of one of the big steel mills said we are broke, you have to understand that we don't have the money to pay you anymore, very simple.
>
> (Govt & Int H 2012)

The socio-cognitive institutions SCIs of the large incumbent SOE's were primarily geared towards economic growth and were not concerned about sustainability issues. This eventually shifted:

> I think at this time, especially the industry where I also was already in at this time, was thinking about growth and no matter what it cost which means no matter what we do with the nature. There was just the big idea of growth and there was a set up in the industry in Austria where this growth was really done because there was a state owned company called 'Gestampheim' Group.
>
> (Firm W 2012)

The shift of industry towards a more sustainable orientation - What was clearly noticeable was that Eco-world, and transitions in the socio-economy towards a sustainability orientation happened within the M1 type of industrial sectors. A possible reason for this is captured in a summary of Academic O's response (2012):

> Eco-world, is a 'green-tech' cluster and would be supporting RIS and influencing RIS to make industry greener. This is only part of the transitions agenda. But it is clear that it played a very important role and has an impact on the ability of society and economy to transition towards sustainability. In the larger clusters, like the automotive sector, (Eco-world is not influenced like this), as they are more driven by market indicators, price of fuel, customer demand etc. So in this way the external economic environment has a bigger effect on the direction large industry takes.

The SOE's demise came with a new focus for industry in general that was driven by new societal goals in Austria, and in the region of Styria. Very importantly, many of the existing competences became refocused as sustainability-oriented. For example, regionally the strong focus on environmentalism led to industry focusing on environmental technologies. Govt & Int B (2012) suggested that many of the larger firms diversified to form part of the clean-tech industry at first without knowing it, and later through actively marketing their firms as 'green' in the clean-tech sector (Govt & Int H 2012).

External influences for socio-economic change - With the break-up of SOEs, came the inevitable breakdown of socio-economic structures, including incumbent SCIs. These were replaced by new social structures influenced by regional political dynamics, and the changing EU socio-economic landscape. There were new visions and new goals. This led to new links between SMME's and other parts of Europe and the world. It heavily influenced SCIs and economic thought patterns of regional actors of private sector firms but other actors and elements in the RIS too. Changes became apparent in their thinking and actions from inward looking endogenous growth models to exogenous growth models in the search for new markets and opportunities (Govt & Int D; Academic Q 2012). The point is, there was a major shift in SCIs, because of these opportunities. With this change, endogenous links did not disappear: they simply changed their shape and purpose. Smaller firms began to seek partnerships with other firms, and then came links with universities and other research institutes (Govt & Int B). This effort to 'connect' and form linkages in the RIS, was eventually supported by the regional government, and further institutionalized. In turn, this led to the strong cluster policy in the region and initiatives like 'Eco & co' (a sustainability network for firms in the '90s), and eventually the cluster 'Eco-world'. These were major socio-economic drivers of sustainability transitions in the region (Govt & Int C & D 2012).

Section conclusion - Although SIS provides a slightly different theoretical emphasis on industrial complexes rather than the regional economy as a whole it adds value to the RIS perspectives. In the context of STs, it is also important, since the emphasis of the research is on socio-economic transitions that influence socio-technical transitions to sustainability. The analysis of the Styrian SISs provided a foundation for better understanding of socio-economic transitions. The derived data and subsequent analysis provided useful insights for answering both the primary and sub-research questions. It offered a good picture of sectoral and socio-economic change in the region over the last number of decades. This is important because,

one of the primary underlying propositions in this dissertation is the assertion that shifts within socio-economic structures have an influence on socio-technical transitions towards sustainability. The sub-code '*shaped and environments*' for example was about understanding how changes in belief systems, culture, politics, policies and external shocks may affect directional change within industry sectors. As a pre-cursor to the remainder of the findings below, two things were learnt: *one*, socio-economic change took place through the change in SCIs, and secondly, SCIs were affected by multiple factors, external to the region, but also internal to it. It was SCIs that drove the new directions of socio-economic change as new goals and visions for the regional economy. The capability and capacity perspectives on the Styrian RIS in enabling change needs to be better understood now from the findings, and is turned to below in answering the research questions more fully.

6.5 Assessing the capacity and capabilities of RIS, and type of SIS in Styria

Now that the socio-economic background of the Styrian regional economy has been briefly described, it is necessary to provide feedback of the findings dealing with answering the following research sub-question: **1a:** ***Do strong, capable and functional RISs have a greater capacity to enable socio-economic transitions to sustainability?***

The aim of this section is to provide evidence from the findings for that research sub-question. Using the analysis framework as a guide, the strength, capabilities and functionality of the Styrian RIS was analysed. In the first instance, a brief reflection on the different perspectives given by the three interviewee groups chosen to reflect the triple-helix network within the Styrian RIS will be provided. The view of strengths of the RIS from each perspective are given first, and then more specific aspects of the strengths and functionalities of the Styrian RIS are provided. At the end of the sub-section a brief response to the research sub-question is provided. As a starting point, it can be clearly stated that the Styrian RIS grew from the challenges it had in the 1980s to become one of Europe's strongest and most capable.

Linked to SCI shifts about sustainability, the company 'eco-profit' was established in the 1980's. This company embodied prevailing social attitudes in formal collaboration with a technical university to solve environmental challenges. It assisted in promoting adoption of environmental innovations and efficiency processes by industries. These were known as 'end-

of-pipe' solutions, and identified with a specific form of SCI. It is interesting to make a link between this 'solution', associated with 'incremental' improvement and the more recent kinds of solutions presented by companies within the 'Eco-world' clean-tech cluster. The latter represent a more fundamental design thinking paradigm, associated to a recent phenomenon: an SCI not concerned with reducing pollution or using less energy, but with a total system re-design of production processes. This SCI led to the 'clean' and environmental technology cluster that emerged in 2005.

'Eco-world', however, emerged from a history of networking activities – like Eco & Co – which was an attempt to bring together industries that were sustainability-oriented in the Styrian region. After the privatization of the SOEs and their shifting to smaller M1 type sectors, there was a big drive in cluster policy. According to Academic Q (2012) the clustering policy and management process had a substantial influence on the RIS, and sectoral development in the region. Part of the clustering process supported certain trends of development and assisted in reinforcing the RIS. No doubt, knowledge generation, private research and university support provided strong drivers to support industrial growth in the regional economy.

Government and intermediaries' (Govt & Int) views - This group, especially intermediaries, contributed substantially to strengthening the Styrian RIS. They are 'lumped together' as 'Govt & Int' because, government often acted in partnership and through triple helix organizations in the Styrian RIS. The most pertinent of the many 'Govt & Int' were approached for the interviews and their viewpoints are included here. Among the findings, a perspective on this group's importance within the RIS over the last three decades was gained. It provided valuable insights into the enablement role that government and intermediaries played in shaping the RIS. These 'intermediaries' included: financial intermediaries (that assisted in providing finance to the RIS components, firms, innovators and entrepreneurs), cluster management organizations, and public-private research institutes and competence centres, all of which had strong 3-helix links. Knowledge transfer and knowledge development is a big driver of change, and these intermediaries played a substantial role in this.

For example, Govt & Int A (2012) suggested that without them there would not have been significant change towards SD. The intermediary AAE-Intec, was a classic boundary spanning organization with a board of directors made up of professors from different

universities in the region and private sector representatives. It was designed to 'fill a gap' in the RIS by doing riskier R&D for innovation in the solar technology and PV industry, sharing its research results and expertise with the private sector. Similarly, the regional financial intermediary SFG, also a business promotion agency, played an important role in stimulating and supporting the RIS of Styria (Govt & Int F 2012). Government allocated resources were channelled through them, knowledge transfer used their networks, and they hosted regular regular events. The next group that was interviewed was academics representing in some instances university's role in the RIS, along with researchers of private research institutions.

Another intermediary, Climate Change Graz (CCG), also played an important role in stimulating regional conversations and interaction about climate change and sustainability issues in their RIS. It did this not only through regularly publishing research and statistics about harmful emissions, but through working with actors in the RIS to promote sustainability-orientations within industry. Information provided by CCG gives evidence of strong institutional support for climate change policy and mitigation strategies between private sector, government, universities and research centres (Govt & Int E 2012).

SFG, the financial intermediary, provided seed capital and financing for not only the cluster development, but also for innovative projects and start-ups in the region. In providing funding for innovation, it often involved collaborative structures between universities, and the private sector. SFG was the most important financial intermediary and government body aiding in and promoting interactions, considerably strengthening their RIS. It did this, not only through providing funding, but also by supporting and organizing regular events that brought specific innovation actors together (Govt & Int F 2012).

Competence centres specifically designed for research collaboration and interaction between industry and universities constitute another type of intermediary. Five competence centres form part of the Styrian RIS, each of them has some focus on sustainability. An example is the Polymer Competence Centre in Leoben (PCCL), a small University town not far from the city of Graz. While this centre does research on polymers, traditionally not regarded as a 'sustainable field of research,' the goal of part of their research focus was to improve the durability of the polymer coatings of solar PV cells to enhance the life-span of the PV product. The problem they were trying to solve is that, over time, the plastic coatings of PV panels become weathered and discoloured inhibiting full penetration of the sun's rays and so reducing the efficiency of electricity production. This was a clear focus by PCCL on the

needs of industry, which was seeking and paying for this solution. Competence centres are designed for interaction in knowledge transfer between universities and industry, and are partly funded by government and universities in their configuration. Once established they seek industry funding for research. A matured competence centre in the Styrian RIS, receives at least 50% of its funding for applied research from industry. This is typical mode-2 type research, the outputs primarily geared for industrial applications and commercialization. These competence centres not only enable interactions between university researchers and industry researchers in the same locality, but also often provide the foundations for industry competitiveness on a global scale (Govt & Int B 2012).

Academic views of respondents - Academic Q (2012) comments that 'generally speaking the 3-helix in Styria, was not that strong [in the past], but it increased and improved and now is in a 'capable' state, and quite strong clustering assisted with this.' From his view, at the time of the study, there was a clear indication of a strong RIS, in terms of funding, industry cooperation and leadership as well as narrow specialized focuses for innovation, driven by industry. Universities and research clearly played an important role in this.

Academic O suggests that the innovation focus in Austria was in fact quite niche. It was not a 'front-runner' in fundamental innovations, like Germany, Sweden, Finland, Denmark and Switzerland. However, it was suggested Austria, and the region of Styria was 'smart in taking up technology [i.e. Technology adoption], but we are still not that strong in our own innovation, in the radical innovation' (Academic O 2012). This was also a contemporary perspective.

There were also shifts in thought paradigms or SCIs in the academic movement in Styria over the last three decades l. For example, thinking about innovation shifted from a focus on incremental innovation, which was a trend in the 80's to more radical innovation thought paradigms in the 2000's. This went hand in hand with the environmental movement promoting environmental technologies or end-of-pipe solutions. At a later stage, this progressed to 'clean-tech' which embodied a different SCI, as a technological design input. Academic M (2012), from a local technical university in Graz, was involved in these shifts of paradigms of thinking about innovation and sustainability, and could confirm the shifts in SCIs. It was the strength of the relationship between the technological university and industry that lead to a co-development of SCIs for more sustainability-oriented innovation.

In discussing change of technological systems in industry, one respondent suggested

> In terms of change of industry, and technological change, society doesn't just reject existing technology: there needs to be something to shift to, an alternative before the 'redundant' technology is rejected.

This reinforces the importance of the ISs perspective on STs, which could take this viewpoint into account. This latter point is interesting for the transitions debate, since it reinforces the notion that ISs are important in creating alternatives for transitions to occur. It was reiterated by Academic M (2012), who made it clear that Styria has a very strong and capable contemporary RIS. He spoke with authority on the matter, since he was a researcher who primarily focused on the Styrian RIS and the various regional clusters as his field of study.

At the time of writing, Styria had an increasingly strong R&D and public sector research capability, which was well integrated into the 3-helix system. It was also funded and supported by the regional and national governments, involving multiple levels of governance of the RIS. The RIS was mostly financially controlled through regional incentives; but, and definitively in terms of research, 'Johanneum ... is one of the institutes or 'private universities' doing specialized research on innovation cooperation, forming a critical strength in their research agenda as part of the RIS' (Academic R 2012).

Finally, politics had a strong influence on the direction of development in Styria, and the clustering process was a strongly politically-driven process. Leftist political movements such as the Green Party were strong drivers of transformation of the RIS towards a sustainability orientation in the 90's and early 2000's (Academic O 2012). Besides national politics, localized student movements put pressure on universities to develop sustainability-oriented curricula. This was a prominent cause of shifting the RIS in a sustainability direction. 'The Universities and university students played a big role in being critical of the 'status quo' and therefore contributed to the shift towards sustainability' (Academic O 2012). Students were also heavily involved in the ecological or environmental movements of the 80s. This environmentalist SCI gradually began to include social aspects as well in the 2000's. This is mentioned, because both the formal and 'informal' political system was 'strong' and should not be discounted in the functioning of a RIS. It is an example of how informal SCIs became formalized within the university system. This kind of formalization process of SCIs is a key finding, discussed in greater depth further below.

From these discussions, it is evident that the RIS of Styria had strong capacities, including institutional support. Research, co-operation and functional integration of the various

elements and mechanisms were evident. From an academic viewpoint, there was a clear shift in the industrial base from heavy industry through state-owned companies in the 70's and 80's to smaller, privately owned, knowledge-based companies. In general the RIS of Styria was seen as becoming more integrated and more capable in the lead up to the turn of the century, and even more so by the 2010's. Although, firms were not really aware of the concept of IS's they participated in them, and were very actively making up part of the system in Styria.

Firm responses – Firm S (2012) gave an interesting view of the notion of progress in the Styrian region. The respondent suggested that a high standard of living is a direct indicator of a stable and functional RIS, and that the high standard of living that characterizes the Styrian region allows society to focus and think about sustainability. He implied that such a socio-economic 'condition' means that they do not have to focus on pressing social issues, such as inequality or unemployment. This view immediately provided a 'snapshot' of the Styrian economic and business condition at the time of the study.

A story by Firm W (2012) may illustrate this point. Focusing on environmental issues (rather than any pressing social issue, it developed specialized UV technology to sort 'Pyrex' glass from conventional glass in the recycling process. In the first instance, the idea of recycling glass arose because of societal pressures to become more environmentally-minded. Making glass was energy intensive and required mining raw materials. Firm W, responded through building networks of co-operation within the RIS and with local knowledge communities and society. Firm W also 'outsourced' the issue to the local university, which eventually, through research, discovered the use of UV, as opposed to X-ray as a safer and less expensive alternative for identifying the 'Pyrex' glass. Firm W was then able to create an innovation, through some support funding from government that led to the automatic filtering and sorting of glass particles in the recycling process. This made the issue of glass recycling commercially viable and was an incremental step towards transitioning the regional economy in a sustainable direction.

The solution was a collaborative one: between the government which reduced the risk, and the university which provided fundamental research; and industry, which shared some of the risk and was responsible for commercialization (Firm W 2012). In response to the RQ sub-question, it was the strength and capabilities of the RIS, which made the innovation for

sustainability possible. This was just one of the several stories of firms shifting towards a sustainability-orientation due to altered SCIs in the RIS.

Firm T (2012) confirmed that the strength of the region's knowledge base was a clear advantage for firms and the regional innovation capacity:

> Styria has a strong RIS, due to its strong research and knowledge base. There are five universities, and several research institutes and technical schools. The research in some of these universities was globally competitive, and still remains so in some cases.

A strong knowledge base within the RIS does not, however, guarantee or determine any direction towards sustainability. The above responses reflect a general introductory discussion about the capacity and strengths of the RIS in Styria, first from a governmental and intermediary perspective, and thereafter from an academic and industry or firm perspective. Below are more direct responses to the 'strengths' of the RIS, as reflections and summaries of the sub-coding categories of infrastructural strengths, interaction strengths, institutional strengths, evidence of capabilities in the RIS, evidence of RIS specialization and RIS policy strengths. This helps to understand in greater detail the qualities of the Styrian RIS capacities and capabilities.

6.6 Findings of strengths of the Styrian RIS

Infrastructural strengths – Competence centres, were one example of physical infrastructures of the RIS that existed to provide physical proximity between university and industry researchers (Govt & Int J 2012). These centres provide physical capacity to enhance the capabilities of the RIS in the region in close proximity to universities. Linked to this, were various technology parks, cluster management centres, incubators, competence centres and science parks (Firm S 2012). These specialized infrastructures are in addition to the more obvious infrastructures of the universities, the R&D facilities that existed within the firms and the campuses of the research firm Johanneum, for instance. From the perspective of the researcher, these assets signalled a highly developed and capable RIS that was embedded not only socially but also infrastructurally.

Interaction strengths in the RIS - Interactions between elements and actors in the RIS signalled not only a strong RIS, but a functional one. The strength of interactions is important for understanding how SCIs may extend within the RIS. Weak interactions don't allow for

SCIs to 'diffuse' as quickly or with the same quality[33] within RIS and in society. SCIs like general institutions provide frameworks for search and research, ultimately determining the directions of innovation systems (ISs) and their outputs. However, it is the interactions between elements that aids their development in new directions (for sustainability).

AAE-Intec is again a good example of how this took place. It was also one of the earliest sustainability-oriented intermediaries, promoting solar photovoltaic (PV) energy within the Styrian region. It was a community-based and grassroots movement eventually becoming a research organization, and it provided leadership for sustainability thinking and practice, through efforts of one individual *'Govt & Int W'*. It also provided training for localized groups of people interested in building solar home systems. In fact, it was at the 'epi-centre' of supporting collaboration in exchanging know-how at the grassroots level for solar PV technology in the entire Styria region, and was based Gleisdorf, 20km from Graz. It prominently promoted the environmental movement and sustainability in the late '70s and '80s. AAE-Intec started from supporting grassroots movements in PV energy in the whole of the Styrian region and grew to promote alternative solar energy and technologies to firms and governments globally. The organization grew, to the extent that it now supports larger private sector organizations with research and development and training in the field of solar technologies (Govt & Int A 2012). It has a board of directors that is comprised of seven university professors from various universities as well as several private sector directors with some government funding – making it a triple-helix organization. It has a large staff contingent doing research, and it provides space for master and PhD students doing in-house collaborative research. The reason for using this example is to illustrate how this intermediary NGO plays a fundamental role in strengthening the interaction and capacity of the Styrian RIS, and, more narrowly, the cluster of 'Eco-world' in the alternative and sustainable energy fields (Govt & Int A 2012).

Another example, of an organization's primary goal to promote interaction in the RIS, and specifically for sustainability, was the cluster management organization, 'Eco-world'. It played and plays a fundamental role in ensuring interactions between elements in the RIS. Its primary mandate was to identify, promote and cluster organizations in the clean-technology sector, or to cluster organizations which were sustainability-oriented. Eco-world grew from attempts by government to build a network of every sustainability-oriented firm or

[33] Quality here may refer to quality of information or knowledge, for example.

organization in the region of Styria in the late '90s, it was called 'Eco & Co.' (Govt & Int C 2012; Govt & Int I 2012). Initially, substantial funding was provided to build this regional network, which comprised over seven hundred organizations (Govt & Int I). This work was initiated by government in 1998, and was the start of building a culture of interaction and collaboration between sustainability-oriented industries.

Another major influence resulting in interaction strengths in the Styrian RIS, was its strong cluster policy supported by government. This political agenda reached its peak in the early 2000s, and 'Eco-world' was in fact one of the last established clusters. The Styrian business promotion agency (SFG) was responsible for driving this (Govt & Int C; Academia I 2012).

Eco-world was the result of considerable effort by both government and the intermediary organizations to emphasise the importance of networking and interaction between organizations in the region. Once Eco-world was established, it became a very strong driver of socio-economic transitions towards sustainability in the region. Govt & Int B (2012) report:

> The strengths have been there, a process having more companies and research institutes in the area than other regions have. At that time we had 5% turnover of gross regional product in 2006, right now, 2011/12 I think we have 9% so this is quite an increase. 9% green tech turnover related to the gross region product. Of course this is apples and peaches, but it shows a good relation with the other regions in average of 1.5%, but we really have a kind of six-fold strength right now in this area, that's why I think clusters is appropriate tool here, having a strength. Having bottom up and top down, both approaches, a mixed approach [is good].
>
> (Govt & Int B 2012)

The emergence of 'eco-world' as a cluster is also a clear indication of the strength and emphasis on sustainability in the regional innovation system. One of the employees of eco-world emphasized this:

> Eco-world cluster management organization plays an important role in strengthening the RIS, especially around interaction strengths. We have ten technology roundtables. Here various issues are discussed with industries, and universities. They try to connect companies who can solve their problems, or they find research support to solve their issues. In general they try to support high quality research, and researchers.
>
> (Govt & Int D 2012)

Another intermediary, not yet mentioned, which also drove strong interactions between elements in the RIS, was the regional industry association. It promoted industrial

development in the region. In discussion with the director ('Gov & Int H' 2012), an overview of the interactions of the RIS was provided in these two statements:

> Universities had a powerhouse of innovation and what's so different in Styria is that they [RIS elements] are working together, that we had natural networks of companies and research organisations and so on.

And,

> …we are getting better and better and better in combining and doing networks and transforming that research knowledge [i.e. commercialization].

These statements were also supported by senior regional government officials, who suggest that the science and technology system of the region is very strong. These strengths of the RIS, are a direct result of the interactions between the various elements and components which were supported and stimulated by intermediaries and government. It was exceptionally clear, that intermediaries were vitally important in stimulating the interactions within RIS. This is something that is not adequately dealt with in the ST and the IS literature – especially in driving interactions towards common regional sustainability goals.

The response from academia about the high levels of interactions within the RIS, confirmed the high level of interaction in the Styrian RIS between elements. Academic M (2012) discussed his personal research, focusing on the intensity of knowledge transfer within firms, between firms and between various clusters in the region. His expertise suggested that the culture of knowledge sharing and open innovation was strong in the Styrian RIS. A perspective shared by vice-rector Academic N (2012), suggesting clear localized interaction strengths. Sustainability concerns were driven 'home' via interaction at the community level in the region, also infiltrating the university systems. The five universities in the region played an important role in the interaction between the elements in the RIS, and stimulated debate about sustainability issues in society and industry. The Universities were thus big 'intermediaries' in the RIS, enabling considerable interaction strengths and providing knowledge for sustainability.

The private sector reinforced the idea of 'positive interactions' between firms and with universities and intermediaries in the RIS. Using the term 'open innovation', interaction and collaboration was abundant from the private sector's perspective. Firm X (2012) said:

> We have a kind of open innovation policy especially in regard to telling your new ideas which are in a certain stage, certainly I'm not sharing everything that we have here, but it's easier to discuss with the companies or with the stakeholders from companies who are not direct competitors.

Open innovation policies in the RIS strongly promoted the importance of organizational and institutional collaboration (Firm T 2012). Interviewees pointed out the strengths in 'partnering with local and national knowledge generators' (Firm W 2012). They suggested that Eco-world emerged because of these types of interactions at the local level, driving 'green elements' in the economy.

To conclude, the strength of the Styrian RIS was clearly evident from the interviews, and through general observation from the perspective of the researcher. The strong interactions in the RIS, also provided a solid foundation for the socio-economic shift towards a sustainability-orientation. However, a final observation which is important to these findings is the fact that interactions were strongly driven and supported by intermediaries. They did not automatically take place.

Institutional strengths in the Styrian RIS – As discussed in-depth, especially in the NIS literature and the work of Lundvall, institutions are vital elements of ISs, and serve to guide their functioning, actions and direction. At the regional level, institutions both formal and informal are found to be prominent features of a RIS. Strong institutions support innovation and economic advancement in general in the Styrian RIS, but also shift it towards a sustainability-orientation.

Eco-world responses provide a compelling view of the institutional strengths and functionality of institutions in the Styrian RIS (Govt & Int B 2012). The manner in which societal problems were absorbed by researchers was emphasized. They in turn developed solutions that could be commercialized. This was certainly true for the sustainability challenges in the region. Govt and Int B (2012) spoke of societal change: 'all those events mentioned, hydro-power, nuclear power, recycling, waste-burning and the science and research followed them to provide some solution'. There was considerable evidence in the analysis that strong and functional RISs were supported by institutional change in the knowledge systems for a sustainability-orientation.

Another institutional strength of the RIS was the ability of organizations like Eco-world to match business with research and build commercial opportunities in a sustainability-orientation. Strong institutions as a collaborative culture have been reinforced by Eco-world, and also pushed in a sustainability direction. According to Govt & Int C (2012) institutional strengths are about the organization of reciprocal needs of society and industry – from top to

bottom, in support of new industry trends. This was certainly present in the Styrian RIS. Govt & Int D (2012) for example suggested that it is interactions, flows of information and knowledge that create opportunities for change and innovation. These flows created a better understanding in terms of industry needs, and externally the capabilities and university research that was available to them.

It was evident that both formal and informal institutions of the RIS supported a collaborative culture. Examples and evidence from the discussions relating to formal and informal institutions in the analysis are mentioned below. SFG, for example provide the financial support (incentives) in partnership with other formal institution of government's regulative procedures. It is clear that from a 'formal institutional' level, there was strong support from government for change through innovation, backed-up by financing. There are strong institutions in place to support new projects that could enhance the economy or create a new direction in the economy.

Strong leadership is an institution that is vital to the functioning of an RIS and for providing new directions in it. This was immediately evident in sustainability thinking in government. For example, it was government that initiated the industry networking process of Eco & Co (Govt & Int F 2012). Another example is the responsibility and lead of financial intermediaries like SFG, which would support new and emerging business. However, they also continued to support new ideas in 'older' businesses (Govt & Int F 2012). This provided considerable strengths and institutional support within the RIS, noticeably in a sustainability direction towards the turn of the millennium. Government and formal institutional support for building the RIS within Styria was strong, especially between universities and industry (Govt & Int J 2012).

The institutional support of bottom-up initiatives from a top-down governance approach was seen as characteristic of the Styrian RIS. According to Academic M (2012) this institution was 'strategically developed' by government. Several examples of this kind of 'automatic' support by government of grassroots initiatives was discovered in the research process. An example is how recycling was started in Styria. It began as a 'grassroots' protest to new landfills being built, which eventually sparked 'recycling' which was relatively quickly institutionally supported by government from the top down (Govt & Int I 2012). It was the quality of the institutional process that was striking to the researcher: it was not necessarily the lack of conflict – but the manner in which the societal sustainability priority was dealt

with by government as 'taken for granted'. In partnership with society and firms, government enabled and supported systemic socio-technical transitions at the grassroots level through implementing learning programmes about recycling within the communities, coupled to new technologies and infrastructures to support this (Govt & Int I 2012).

Another 'stand-out' institution, of a more informal nature was the level of collaboration, trust and interaction between firms. Open innovation was promoted and practised between most of the SMMEs in the region at the time of the study. For example Firm W (2012) explained that it was through their networks that people brought ideas to their company, and they used this to their advantage. Accordingly, many other companies in Eco-world had an open innovation policy and readily collaborated.

In the Styrian RIS, the systemic approach to collaboration and interaction can be viewed as the work of a special kind of institution that provides the conditions for rapid socio - economic and socio-technical systems transitions in society. Several other examples of socio-technical system changes in the region were revealed in discussion with respondents, including large scale grassroots solar PV projects, solar heating systems, wood-fuel technology, biofuels and bio-diesel generation, glass recycling and transport systems and several other sustainable innovations. It was clear in all these examples that a strong interaction within the RIS enabled not only economic strengths but also the ability to transition to new socio-technical systems for sustainability in society.

Strengths in capabilities of the Styrian RIS – From the analysis of the data, and through the experience of the researcher it was evident that the Styrian RIS was capable. One of the respondents, Govt & Int D (2012) gave reasons for the strength in capabilities which are firmly linked to the strengths of interactions and institutions. He suggested, 'needs are known and these needs are connected with the right resources – either other companies, or universities or finance from government' (Govt & Int 2012). This implies that interaction and institutional strengths result in capability strengths. However, capabilities also stemmed from a strong industrial foundation in the region and a strong knowledge system coupled to the more recent cluster policies of the '90s and 2000s. The older industrial clusters in the region, including the car and steel industry also provided a transfer of capabilities, in the form of skilled labour that shifted into the eco-world cluster and green industries through time (Govt & Int A 2012).

Intermediaries played an important role in shaping the capabilities of the region to match industry needs, especially in a sustainability direction. Eco-world and many of the other intermediaries were constituted as 3-helix organizations and hence understood the capability needs within the RIS. This included understanding gaps and organizing capabilities for the effective functioning of the RIS on a continuous collaborative basis. This wider awareness was achieved, for example, through various facilitated roundtable discussions between government, industry and universities to ensure synergies between research and economic goals. The role of government was to assist in planning, through policy changes, changing legislation and providing finance for steering the economy. It was evident that this was done continuously through effective planning. This led to the improved functioning of the RIS and to its associated firms becoming increasingly competitive in Styria (Govt & Int D 2012; Govt & Int F). Competence centres, as the name suggests, also provided specialized capabilities for the RIS. This is because the researchers and technicians that work there were somewhere between industry and academia. They provided useful knowledge, and built specialized capabilities that enhanced regional competiveness in one instance, and in many cases also regional sustainability. Govt and Int G (2012), director of one of these centres, suggested that competence centres played a vital role in the RIS. He said, they service government through effective public spending, and universities in bringing practical knowledge into the university system. This competence centre influenced university research quite strongly, because it provided funds and in this way steered the direction of research. While it is clear that individual competence in terms of skills and capabilities existed within the RIS and in firms, the competence centres were about the organizational institutional capabilities provided for by universities and intermediaries (Govt and Int H 2012). There were five competence centres founded by universities that provide capabilities in Styria. Technology transfer offices also specialized in the transfer of knowledge and capabilities in the RIS. Both these organizational research institutions are university 'boundary spanners' providing a clear indication of mode-2 research and applied sciences supporting the RIS in Styria. They signalled strong support for building a capable RIS (Govt & Int J 2012).

The private sector provided few additional insights into the notion of capabilities. However, the role of the individual entrepreneur in the region was an important capability that led to several socio-technical transitions. This was seen as a unique individual capability that characterised the Styrian RIS.

RIS specialization - Another aspect of strength inherent in the Styrian RIS, was its specialization or sector focus and clustering. This is linked to the notion that Austria and Styria, as a smaller nation and region, needed to focus their limited resources. In the past, a strong industrial focus was present in several areas of specialization including mining, steel production, timber, paper and pulp and the car industry. These focus areas all became clusters, after which a new specialization for the region emerged – clean and environmental technologies. Eco-world cluster represented this shift to a sustainability-orientation: it had a cross cutting influence towards sustainability on all the other clusters (Govt & Int 2012 B). Within Eco-world, there was also specialization and focus areas for innovation included water, waste-water, energy, bio-energy, solar-energy, solar-heating, wind-energy, recycling, and transportation (Govt & Int D 2012). The focus of competence centres and private sector research on these 'green' focus areas considerably enhanced specialization in the RIS, which improved its competitiveness regionally and globally (Govt & Int J 2012; Firm V 2012). The importance of specialization within the RIS, was that limited capabilities were channelled to the various industries and elements supporting a particular focus, for example sustainability. This kind of strength was supported by policies which are a strength in their own right. Without adequate policies supporting innovation activities and specialized directions, competitiveness wanes.

Policy strengths – Policies for regional development change over time. In the Austrian and Styrian landscape in general, there were fundamental policy changes over three decades from 1980. These included a strong policy focus on supporting large state-owned enterprises – which eventually disintegrated. This was replaced by strong regional development policies that allowed for cluster development policies to be implemented. Strong political leadership to start a car industry in the Styria region led to the car industry cluster. Likewise, politicians and government administrators made policies to favour innovation generally in the region but also witha strong bias towards sustainability in recent years. The concept of 'Ekosoziale Marktforschung' (ESM) was an Austrian-German political concept of 'socio-ecological markets'. It translated into policy support for sustainable development in the region of Styria, at an early stage. ESM, certainly assisted politically in the support for concepts and projects like 'Eco & Co', 'Eco-Profit' and several of the bottom-up sustainability initiatives already mentioned (Govt & Int I; Govt & Int F; Firm S). Academic R (2012) suggested that there were strong demand-driven innovation policies, driven by societal needs which included sustainability concerns. This was certainly regional, but also came from the Austrian national

level. 'At national level, there is a strong agenda, especially in some of, in quite a few ministries, or in public procurements and it's more orientated towards sustainability issues' (Academic R 2012). Although there was support for sustainability and innovation policies it often takes a long time to introduce them and in some instances fails as expressed by Academic O (2012):

> We have really increased a lot emissions of the automotive sector, the use of cars and we are discussing these issues for 10, 15 years that we would need to change our policy so that it would be cheaper for people to live within the city, to reduce the amount of people living in the surrounding areas so that everybody has his own house, shorter distances to school, jobs, universities, whatever. We discussed this in 10, 15 years that we need to improve the public transport – but we are not able to do that because we are not able to manage systems in a systemic way.

Sub-section conclusion - The various strengths of the Styrian RIS, have been discussed above. To provide part of the answer to the research sub-question (1a), it was clear that the Styrian RIS was not only strong but also capable. A more detailed description of these strengths provided above followed the sub-coding categories. The findings suggest a clear link between the ability of a RIS to be sustainability-oriented and its strengths. Capabilities are also fundamental in providing the capacities for sustainability-oriented RIS.

6.7 Findings on the degree of functionality of the Styrian RIS

As described in the literature review, functions of ISs are a deeper approach to describing their components or elements. Functionality of IS's goes deeper in describing the functions and purpose of not only the elements in the system but also the dynamics between the various elements such as universities, firms and government (Hekkert *et al.* 2007).

The Styrian RIS was functional for several reasons, and went hand in hand with RIS strengths like 'interactions' between elements. Academic Q (2012) summed up the importance of interactions. If more knowledge is gained about the subject of sustainability, this influences the trajectory of the ISs. It also changes the way new markets are created through societal thinking and preferences. According to Academic Q (2012) this shifts socio-economic trajectories:

> In general, what we see of course is that the more knowledge we gain about, I would say, the link between very different things like energy consumption and climate which are disparate things – that is very much changing society. That is very much changing society in a way that new markets are created, that new knowledge is actually driven and asked for, that we see new business models emerging.

It is clear, therefore, from this perspective, that knowledge development, which is first on the list of 'functions of innovation systems', is a vitally important factor for transitions through

an innovation system. Knowledge development is about the availability of knowledge, access to it and the interactions in the RIS that enhance its functionality. Knowledge that is sustainability-oriented no doubt has the biggest influence on SCIs, leading to formalized structures to support innovation for sustainable development in the RIS. The most prominent and important functional strength of the Styrian RIS from the researcher's perspective will be discussed below.

Knowledge and knowledge development –In the four decades since 1970, there has been a substantial increase in the R&D capabilities of Styria. This has had a direct influence on the capabilities in the modern RIS (i.e. 1990s to the present). These did not necessarily stem from universities, but often from the private sector. Only since about 1990 have universities begun to align their research to industry needs. At the time of writing, Austrians had a healthy economic self-image, especially due to the quality of their research and private sector R&D, and that was partly why Austria and Styria had a strong and capable NIS and RIS.

Changes in the social and economic landscape, and various environmental pressures, also influenced the knowledge system of the region to shift towards a sustainability orientation. This signalled responsiveness of the RIS to sustainability pressures, through institutional change. This 'responsiveness', however, also took place as a result of strong interaction between 'science and economy' between 1990 and 2010. (Govt & Int B, I & D 2012). Notably the cluster of eco-world is the extension of local capacities and capabilities to international levels. This has further enhanced the capabilities and exchange of knowledge between the region and international counterparts.

Knowledge development was the most important driver of change. In Styria, in the past and more recently, there was a strong emphasis on knowledge development. This apparently also has an impact on the direction of the RIS towards a sustainability orientation as suggested by Govt & Int A (2012) who said: *'I think we have to work on knowledge, it's more and more a knowledge-based society instead of producing something'*. This respondent as well as others suggested that the reason why Styria is leading in the field of sustainability is because of knowledge of sustainability in the RIS, through a *'strong university presence, and knowledge generation in this direction'* (Govt & Int C 2012).

The government of Styria has also placed a large emphasis on knowledge generation – spending 4.3 % of Styrian GDP on research and development, high above the national and EU average.

> So we have a research quota of 4.3 %, which is pretty high, but I still believe that more research... comes out from companies, from large sized companies, from private research organisations, because there, for them it's a kind of need or a necessity to produce research results and the university/ies have a shift over the last five to eight years. There is a general shift in the regional university system to produce knowledge to support industry, and especially towards a sustainability direction.
>
> (Govt & Int D 2012)

Knowledge development, as described by both Govt & Int F and G (2012) is also influenced by and responds to the needs of society. There was a strong emphasis on applied sciences, both through vocational training and specialized research in the competence centres. However, often because industries funded knowledge development via the competence centres they also determine research directions. If there are 'gaps' in the knowledge system, then the intermediary organizations, like SFG, try to broker them.

More recently, in the clusters for example, there is 'huge internal R&D' taking place, which enhances the entire capacity of the regional RIS (Academic K 2012). In the past, unlike at the time of the study, research in universities was not geared towards servicing industry. This became more and more prevalent with both cluster policy influences (Academic M 2012) and technical universities and competence centres (Academic l 2012). Competence centres were described as:

> Public private partnerships and organizations very much based on the knowledge of the university, in the interests of the industry and being in the situation of not being an academic body and not being a real company, they have a certain specific role they play very successfully – the competence centres.
>
> (Academic K 2012)

Several academics discussed the importance and shifts in the role of knowledge development from a university perspective. On the one hand there was growing pressure on them to 'disprove' the 'ivory tower' perception and place more emphasis on applied sciences; and on the other hand there was a need to retain general scientific interests (Academic N 2012). This kind of pressure from society to become more relevant, coupled with interactions with students and staff resulted in a demand for sustainability sciences. According to Academic O (2012), the first programme in environmental technology in Austria was offered in 1992. This university approach also began to filter into the RIS, through research, and through

employees in firms who had gone through this training. That had a significant impact on the direction of the RIS in Styria, as was emphasized by Academics O, l & R (2012).

This message was repeated again from the firm interview perspectives. For example Firm S, suggested 'there is a lot of fundamental knowledge available in Styria, we have good knowledge in materials and so on, mechanical construction, electrical engineering, so it's able to support the industry with knowledge' (2012). Interestingly, Firm T (2012) was not of the opinion that University knowledge was useful for industry, nor that it led to innovation. He suggested there remained a gap between their knowledge and knowledge that is useful for commercialization. This was however, refuted quite strongly in the evidence of universities working closely in partnership with private sector firms that led to many of the sustainable innovations in the region including bio-fuels. The following two excerpts, from an interview with Firm X (2012) explain commercialization for sustainability in the case of bio-fuels:

> Definitely, definitely, to put it in a time frame so to say, we had the crisis '79, the university started to investigate throughout the '80s and in '91 we built the first bio system, which was a clear outcome of research.
>
> The crisis '79, there was for the first time the challenge for the science, to find new alternative energy and Prof [M] was our [Firm X] exclusive researcher for a long time, a research partner, he's coming from organic chemistry. His task was within his field to find a new chemical which has a similar burning characteristics as mineral oil diesel in an engine so that we don't have to change the engine, but to be originated from something we can grow locally or we can produce locally. So this was his task and this professor, so he started to investigate the possibilities and found then the method to change vegetable oil, fat, into a diesel like molecule.

Entrepreneurial experimentation – Coupled to the important emphasis on knowledge, was the role of the entrepreneur in the RIS. Entrepreneurs and 'innovation champions' played a vitally important role in the transition of the region of Styria towards more sustainable socio-economic pathways. Innovation was driven by a few entrepreneurs in the region of Styria, and this started as early as the 1980s, when there were already entrepreneurs experimenting with solar thermal and wind energy.

Not only innovation, but also entrepreneurial thinking was important for shifting businesses and industry towards experimentation. Innovations required entrepreneurs or entrepreneurial activities to take them to market. Another sign of a strong RIS, was the level of entrepreneurial support received from the RIS mechanisms through co-financing and through political support (Govt & Int A 2012); which included sustainability-oriented innovations (Govt & Int B 2012).

Several globally relevant SMME's began as entrepreneurial ventures that were reacting to sustainability issues (such as waste problems) in the region in the 80's (Govt & Int I 2012). Pressure from society and from the regional/national government – i.e. bottom up and top down pressures – simultaneously created the opportunity for entrepreneurs to solve societal problems like waste. In the RIS, entrepreneurial solutions for waste were supported by government, reinforcing their activities and actions on the grassroots level. One example was alluded to, that of a specialized technology (Komptek) used for composting, which was being exported on a global scale.

Going deeper, one academic respondent M (2012), made an interesting point about how entrepreneurship was fostered in the region through macro-economic structural change. A big shift towards entrepreneurial activity and innovation took place when the SOEs became unbundled. This created opportunities for smaller firms and entrepreneurs to excel. Universities began supporting entrepreneurial activities, fostering various education programmes that allowed for entrepreneurial thinking in the region (Academic N 2012).

To conclude, entrepreneurship and 'experimentation' was seen as an important driver of change towards sustainability in Austrian society and specifically in the Styrian region. One interesting perspective for why entrepreneurs took up sustainability challenges came from Academic Q (2012) who said:

> I think this is one of the interesting points that also comes from societal pressures because those [entrepreneurial] experimentations are done by people that actually say – I want to bring in what I am as a private person into my professional life.

Institutions, as well as societal pressures were responsible for the quality and kind of entrepreneurial experimentation that took place. For example, in the private sector responses, many of the firms were examples of early entrepreneurial experimentation. These included entrepreneurial activities in energy, bio-energy, heat-energy, solar-energy, recycling and various other clean-technologies. One firm respondent however, summed up the importance of institutional support for entrepreneurs, which was a clear strength in the Styrian RIS:

> Yes and focussing on these little guys, it will be hard with some, when you want to define the good structure, when you want to define good foundry conditions for such motivated entrepreneurs. A direct subsidy is sometimes a help and is maybe sometimes needed, but is perhaps not the most important factor. I think the most important factor is, if you see this as a plant, where you plant the seed and you bring water that it has its humidity and the plant starts growing, you need to give boundary conditions where these specific founders can survive and can grow and bringing this for example now to the topic of renewable energies, it is no question at all for me that many different types of renewable energy will come out strongly but the questions related to this the energy price of the competing fossil energies.

(Firm Y 2012)

The direction of search – ‘The direction of search’, as described in the literature refers to the cognitive frameworks that entrepreneurs, SMMEs, or technicians for example take in their ‘search’ for solutions or new directions for innovation. In this ‘function’ it was found that there were multiple factors that impacted on the ‘direction of search’. For example it was not only market opportunities and consumer preferences which were a big driver of demand, but also innovation push, and the entrepreneurial spirit, literally in the minds of society (ie. SCIs) that led to new markets (Govt & Int B 2012). Two good examples are wood bio-mass boiler systems and solar thermal energy. The wood boiler manufacturers saw an opportunity for using the abundant timber resources in the Styrian region. At the same time it was an economic opportunity for farmers. Similarly, the solar thermal energy heating and storage began as a small scale and localized set of experiments from a group of ‘technicians’ who ‘searched’ for new solutions to heating. This search in a new direction for innovation and sustainability, resulted in one of the largest and most advanced companies in ‘flat-plate’ solar collector technology in the world (Govt & Int A 2012).

In response to the question why these founders ‘searched’ in a sustainability direction the following explanation was given:

> Ja, so what is the driving force? People working in the field I think they are believing in sustainable development, that’s something that is important for our society world-wide, it’s the only way to go, so if you’re on energy technology you have just to weigh the two possibilities – either you go nuclear or you go renewable – there’s no other option. And besides this of course, there’s driving forces, there’s a huge potential, people believe in it and at the end companies want to earn money.

(Govt & Int A 2012)

Another major influence on ‘search’ was the more recent ‘green technology research strategy’. It was administered and driven by Eco-world cluster, in partnership with universities, having a major impact on the direction of search in the RIS overall (Govt & Int B 2012). Again intermediaries like the cluster management companies, and financing structures like SFG also had a big influence on the direction of search in the private sector (Govt & Int F 2012).

These ‘search’ push factors, as SCI of innovators in the RIS, are in many instances also driven by need or pull factors – ‘so if you look at investment decision everywhere, you look where are the trends, where are the growth rates affected, and these growth rates are always

based on, for instance, shortage of energy, shortage of materials, some sustainability needs' (Govt & Int G 2012). Furthermore, it was also suggested that in competence centres, for example, government influences the direction of search the least: it is driven primarily by industry that supplies the finances and 'need-problems' for university researchers to solve for them (Govt & Int G 2012). But society trends and fads also more informally affect these markets, and influence search directly (Govt & Int H 2012).

Research directions are traditionally influenced by academic curiosity, but more and more by social concerns and needs (Academic N 2012). However, a strong case was made for the importance of education that influenced SCIs, especially at the school level. Education and training produces graduates that are trained to think in certain ways and in certain directions. They become equipped with necessary skills, relevant to sustainability (for example) that are slowly transferred to industry (Academic l 2012).

Finally, according to Academic P (2012) the way in which thinking takes place as a 'time-horizon of search' also influences its direction. Short-term thinking can be a problem, and longer term thinking may include broader issues like SD – resulting in two distinct SCIs. This was an interesting discussion, because it was suggested that 'lay society', does not in fact understand sustainability, but is more responsive to pressures when it feels them in the short-term, as it did in the financial pressures of 2009. Another academic, however, suggests that society is the fundamental driver of search in RIS, and that in Styria there was a quest for a: 'Utopian vision of our future of our society of Austria' (Academic R 2012). To enable these visions and new directions of 'search', being able to access and mobilize resources to achieve is as important for socio-economic transitions. The systemic nature of dependency of one 'innovation function' on the other is apparent.

Resource mobilization – In the case of the Styrian RIS, recently and in the past it had an abundance of resources both in terms of access to financial support as well as human capital. These are regarded as the two most important resources in an IS. Govt and Int B (2012) had the view that the Styrian RIS is well resourced in terms of skills and capabilities, due to the number of universities serving a relatively small population. Financial resources are available, but depend on the product or idea of the innovation (as in any other situation regarding investments). The intermediary SFG, played an important role in providing financial resources in the Styrian RIS, especially for riskier projects (Govt & Int F 2012). Academic R (2012) suggested that a lot of the financial resources available were dependent

on co-financing which reduces the risks to government, researchers and firms. Universities are also being forced to find funding for their own research from sources other than government i.e. industry. Resources were not only financial, but also included 'skills' and 'human resources,' as suggested by Academic l (2012) Those provided by the five Universities in the region were excellent. In terms of the need for shifting the economy towards sustainability, Academic S (2012) suggested that there remained a dearth in the output of sustainability-oriented graduates at universities. Coupled to the above functions of innovation systems, was a very powerful driver of change – market formation.

Market formation – Markets and market formation were vital to the formation and influence of the RIS towards a sustainable trajectory. Eco-world (Govt & Int B, C & D 2012), made it clear that at first a strong home-market was established. Thereafter the clean-tech cluster and green industries grew strongly towards servicing international markets. This growth is explained below:

> So Eco-world's group of companies perform better (19% growth) than global average (10 %) growth. Their exogenous networks to other global platforms and cluster association bodies assists them in findings new markets (e.g. ICN, and GCCA). They have delegation visits to other countries, to understand market opportunities which includes the rectors of universities etc. They also look to funds from EU to support new clusters, internationally. There markets are primarily export (87 %), but they still have and had a home market (but it is small in comparison to their export market). But with globalisation, there was a kind of necessity for companies to look beyond the borders and so I believe, most of our companies – at least the middle size and large size companies are very globalised.
>
> (Govt & Int B)

Markets were also formed through new legislation (Govt & Int G 2012; Academic K 2012); for example, the extensive change in markets when legislation was put in place to privatize the SOE's. This lead to dramatic SMME growth. New firms responded to legislation on the regional, national and EU level for servicing sustainability needs (Govt & Int K & J 2012). In general, market formation was perceived as a big driver for the clean-tech and sustainable industries. The eventual clustering of these industries promoted both a home market for sustainable products and services and promoted these industries for international needs (Academic O, P & R 2012). The formation of these markets, created power impacts on the regional economy itself, but also increased the possibilities for socio-technical transitions for sustainability in the region. These markets, technologies and innovations were legitimized by society, and this reinforced a momentum towards the transition to sustainability at least socio-economically.

Legitimization – The legitimization of innovations and new technologies goes hand in hand with markets, and demand for newly created services or goods. However, generally speaking, according to Govt & Int A (2012), legitimization of technologies is formed in social networks, within the RIS, but also between businesses as well as international partnerships. Legitimization of a new technological niche is about partnerships and belief in the new technology. Demonstrations and partnerships with universities are also a pathway to legitimization of new sustainable innovations and technologies in society. Academic P (2012) suggested that legitimization of innovations comes about through pushing them into the market: if they are accepted they are legitimized. Another aspect of legitimization was that of sustainability-oriented innovations and technologies, which need to be 'approved by society' as meeting these needs (Firm S 2012). Firm T (2012) said that for entrepreneurs, legitimization takes place through incremental growth of their firms and organizations over time. Legitimization was a key signal of change, from a socio-economic perspective of sustainability transitions.

Positive Externalities – It was clear that intermediaries played a vital role in effecting positive externalities in the RIS. In many ways these intermediaries, which were often partly government funded, were seen as providing public goods. Their services provided positive externalities for innovation and value creation in general, but especially in the Styrian RIS towards a sustainability-orientation (Govt & Int A 2012). Following on from this, Academic M (2012) suggested that incentive structures for 'green innovations' should and can be legitimized by the value of the positive externalities that they create (for society and the environment). Academic R (2012) suggested that the large amount of research and development in the Styrian RIS, on topics of sustainability has a powerful impact on the region. Universities thus service a positive sustainability externality for the region, nationally and even globally. Several of the firms that were interviewed also had strong positive externalities for sustainability in the service offerings of their business. For example, the service offered by the wood fuel technology company had a business model and product that created positive environmental externalities. It reduced carbon emissions, and created jobs and extra income for struggling farmers, thus including social gains as well (Firm v 2012).

Sub-section conclusion - In brief, Styria had and still has a strong and highly functional RIS. It is clearly deduced from the findings that the strength and the functionality factors of the Styrian RIS provided the foundations for both socio-economic and socio-technical transitions

to sustainability. To generalize the findings, the degrees of strength and functionality have a major influence on the ability of regions to transition their socio-economy and socio-technical systems towards sustainability.

6.8 Assessing the general weaknesses and failures of the Styrian RIS

This sub-heading introduces evidence and answers associated with research sub-question 1b: *Do weak RISs have less capacity to influence socio-economic transitions to sustainability?*

The Styrian RIS, was not always strong and functional, as described above, and in fact had considerable weaknesses. More so in the past than recently. There were some obvious weaknesses in the RIS, during the economic crisis of the '70s and early '80s which were cause by the economic restructuring. However, there existed only some issues of concern for respondents in the more modern Styrian RIS from the '90s onward. What is interesting however, is that with the break-down of SOE's in the '80s a whole new RIS system developed. It was one that was far more sustainability-oriented than before. But, several weaknesses and RIS failures existed and continue to exist. They should be discussed briefly in context of the research sub-question i.e. how they possibly impact socio-economic transitions to sustainability in the region.

The thinking and adoption of the ISs approach was not yet prevalent after the break-up of the SOE's (Academic M & O 2012). However, this weakness forced changes in the RIS institutions supporting firms (Govt & Int H 2012). It was only with the focus on clustering that the notion and policy-actions of RISs were instituted by the Styrian regional actors. Although there were existing strengths in industry, such as capabilities from the SOE's; as well as strong research capabilities in the universities there were weak connections between the RIS elements. Most notable was the 3-helix connections, which only really began strengthening around 1998 (Govt & Int C 2012). Academics Q & L (2012) for example both suggested that universities didn't lead innovation at all: it was done within the private sector in the '80s. This suggested that there were some systemic weakness in the innovation system servicing industry at the time.

However, research support for economic competiveness of the SOEs did exist (Govt & Int J 2012). After the break-up of the SOE this was also a weakness because this research was quite locked-in to servicing the old industrial base. The SCIs of 'economic growth at all costs', had been supported by university thinking at the time. University knowledge

production needed to go through a shift of its own to service new industry trends – one of which was SD. Considerable restructuring took place to support the new M1 type format of industrial clusters:

> The entire Austrian state and government did not have enough money anymore to go further with their state owned industrial companies, so they started to split them up. They started to bring in private ownership. And also then they realised that we were on a very low level in terms of innovation, at that time in my personal memory because we had focused on heavy industry, materials and things like that and then also the government realised that they had on the one hand to reduce our own share on these companies and also we had to renew with more innovation in industrial clusters.
>
> (Academic O 2012)

During this time, the general socio-cognitive institutions were also geared towards servicing the state-owned enterprises' innovation needs – which were fundamentally incremental. This was a clear institutional failure, both economically and for sustainability at the time, because it led to deeply locked-in incumbent and bureaucratic industry – which dampened any efforts at radical or system innovations at the time (Govt & Int J 2012). This was an important weakness, because the inertia of 'doing' incremental innovation remained for several years after the privatization occurred. While the RIS grew and restructured its institutions to support an entirely new socio-political and administrative dispensation from the '80s onwards, the socio-economic culture and institutional memory of the past remained a force embedded within the prevailing SCIs in the RIS. It took many years for the RIS to become more interconnected especially between the 3-helix players. However, while slow transformation of socio-cognitive institutions took place in the macro structures in society, the entrepreneurial culture at grassroots level blossomed. Bottom-up initiatives grew from strength to strength in the way they not only made use of the RIS, but also formed part of it. These bottom-up movements, which infiltrated and transformed the older economic structures in the RIS, simultaneously also pushed the RIS in a sustainable direction. This is because many grassroots movements were reactions to the environmental movement and crises in the '70s and '80s. The Styrian RIS's weaknesses and restrictions were transformed into strengths through a different focus on innovation driven by novel SCIs.

In the more modern RIS (90's – 2010's), there also existed some weaknesses and structural issues which may have hampered socio-economic transitions to sustainability. In some instances there was a lack of specialized skills and capabilities, for example 'green engineers' (Academic R 2012; Govt & Int D). Some skills and capabilities losses took place in Austria as a whole when it entered the EU. Another issue, specifically in the formation of Eco & Co,

and Eco-world was the lack of specialization and focus: the 'green' cluster formed, there was considerable disparity in its focus. The cluster was pulled in different directions by politicians and community who emphasised different 'green' aspects. This may have been due to differentiated ideals or SCIs about sustainability: in the words of Govt & Int C (2012) 'it was not so easy to bundle this interest and that was one of the main focuses'.

In the 80's and even up to the 90's there was little institutional support within the RIS from government for the many sustainability-oriented grassroots movements and start-up firms. But, according to Govt & Int C (2012), this is when these institutions began forming, and they eventually strongly supported new emerging sustainability-oriented sectors in the economy. Entrepreneurial support, as suggested by Govt & Int D (2012), has improved in the RIS, but remains weak as compared to other regions in Europe.

Finally, the existing system also had signs of almost overcompensating in its support for industrial research. Although the R&D system in Styria had transformed from little public research to support industry, this had changed to a situation where universities perhaps had become too invested in servicing industry needs. The structural and institutional rigidity of combined university-industry funded research may have locked the RIS into unsustainable patterns of research. From a sustainability-oriented ISs perspective, this would be seen as a failure of that system. Several respondents warned that when universities, or competence centres rely too heavily on industry funding, industry begins to dictate the direction of the research and search. Often the industry needs are for short-term solutions, which translate into incremental innovation for industry, whereas what is needed for sustainability are more radical innovations and system innovations, which are difficult to attain when research in the RIS is dominated by industrial needs (Govt & Int G, J; Academic Q 2012). Govt & Int G (2012) makes this point:

> Because academia has the increasing pressure to get external funds and if doing so of course industry gives the research direction. So if you have this model, research should do research to get new concepts and if there is nothing, there is nothing, but we [PCCL] know more, we have more knowledge. We of course, we are more directed to combining knowledge, and if research is going to be very much driven to industry needs, then I think we, in the long run will lose a lot of knowledge capabilities.

Another final comment about the weaknesses in the Styrian RIS, is the notion that society in general understands sustainability only at a superficial level (Academic P 2012). There is a need to improve the general institutional support for sustainability and leadership towards a deeper understanding in the RIS in general.

Section conclusion – Although there was not an extensive analysis done on the weaknesses of the Styrian RIS, those that were revealed were adequate for answering the research sub-question. To explicate this - most notably were the systemic incongruencies between the 'knowledge system' and the requirements of the 'economic system' in the newly established industrial sectors (after the SOEs were privatized). One generalization, is that there needs to be a careful balance between publicly funded research and private sector investments. An overzealous amount of funding coming from industry may lock-in university resources and research in undesirable directions, hampering sustainability transitions. Knowledge is a clear driver of progress, but knowledge generation can take many directions. In the case example, competence centres provided much needed support to industry, but they also drove a short-term research agenda. This did not allow for longer-term focuses for R&D, and with that more radical or systemic innovations for sustainability.

6.9 Findings of investigative Theme II

The findings of investigative theme II, support the notion that socio-cognitive institutions are built through interactions and connections between the elements in the RIS. These interactions between elements, influenced not only informal SCIs, which included the shallower perceptions, cultures, values, attitudes and norms of actors, but also formal SCIs as deep cultural trends, worldviews, formal knowledge, education and tacit knowledge. However, SCIs were often not shaped through interactions at all, but rather by events, trends and shocks in the markets, or through politics that were beyond the control of any groups or individuals. More formal SCIs as formalized knowledge, skills, deep culture and learning were more difficult to change and took time to change. Formal SCIs existed both within the RIS, but also outside of it at higher structural and scalar levels like the Austrian or EU level. The difference between spatial scales and structural levels and how they may affect SCIs will be touched on in this section in anticipation of the findings in investigative theme III, of which it is the focus.

As described above, there was a fundamental shift from M2 type industrial sectors to M1 type sectors after the privatization of SOE's. With these shifts, both formal knowledge systems and informal social systems within the RIS changed, having an impact on the direction and qualities of SCIs. These SCI shifts supported and guided the RIS towards a sustainability-orientation in many cases. In the formal sense, the various large organizational components of the RIS, such as universities and research institutes, responded slowly through societal

needs. Universities, especially technical universities, became far more responsive to industry needs over the period. However, as previously mentioned, there was simultaneously a strong social movement towards environmental protectionism during this restructuring and privatization period. This social environmental movement was seen as an informal SCI that had a dramatic effect and power eventually leading to more formalized SCIs developing through research programmes adopted by the universities in the RIS. For example, at the time of the interviews, Eco-world had formal research support from five universities. There was a formal 'green-tech' research strategy supported by research chairs at several of the universities in the region (Govt & Int B & K 2012). There were also various other research programmes in the research institutes and universities in the region supporting sustainability-oriented innovations both for new and existing businesses. Many of these formalized SCIs were developed over time from wider informal SCIs in the region.

In the Appendix D6, shows the % of coded segments that were associated with Theme II. This provides a view that most of the discussions centred on the notion of elements in the RIS, and the various forms of proximities. Figure 4.6, also in Appendix D6- Austria theme II is a more detailed table of coded segments and the various sub-codes that were investigated.

6.9.1 Socio-cognitive institutions and influence on the direction, qualities of RIS and regional economic development

This section seeks to provide evidence for answering the research sub-question 2a: *How do SCIs within RISs have an influence on the direction and qualities of innovation outputs in the regional/local economy?*

6.9.1.1 SCI within the elements of RIS

There was a sure connection between the general societal movements in the '80s that fostered informal SCIs in favour of SD eventually becoming formalized in the RIS (Govt & Int B & C 2012). The external validation of the influence of SCIs supporting sustainability in the Styrian RIS, is the known socio-economic transitions to sustainability in the region, evidenced in the growth of the clean-tech cluster Eco-world, but also in the further institutional support it received from the RIS. An example of this is the five strategic leverages of Eco-world to enhance its position in the RIS. (Govt & Int B 2012) describes two of them:

> …one is to have better strategies in the companies, another one is to have an innovation home market, you don't want to have the home market for the whole of the product but we want innovative products to be demonstrated in our region so that the companies can benefit, and show it to the international companies.

As this explains, an important part of changing SCIs in the RIS is to showcase innovations in the region. Two prominent examples that are symbols of change for sustainability in the infrastructural fabric of the city of Graz are described as 'showcases' here, and also as validation of more socio-technical projects for sustainability in the region. The first and most recent showcase is the Gratz smart city project, aimed at transforming a section of the city into a sustainable, smart precinct. This precinct aimed at harnessing local technologies (Academic O & P 2012), and showcasing them there. Secondly, solar panels erected on the wall of an 18th Century monastery in the heart of a UNESCO world heritage site in the 'old town' of Graz was another classic example of SCIs resulting in tangible showcases in society. This symbolized the strong importance of implemented change of SCI for sustainability even within old religious institutions, like a monastery. These 'infrastructural' showcases were symbols of changed perceptions, and a willingness to implement that shifted SCI towards a sustainability-orientation in the city of Graz.

In discussing the manner in which elements in the RIS interacted, the researcher learnt about the way in which SCIs developed. A strong focus on sustainability-oriented SCIs as a theme within the RIS, and how these influenced the direction of the RIS was investigated. These SCIs, were shaped differently through different forces, in some instances through smaller interest groups and communities of practice at the grassroots, and at other times due to shocks, events and legislation at wider levels and scales. Each of the elements in the RIS contributed to, or rejected, the SCIs in different ways. However, most of the SCIs for sustainability diffused within the RIS, first informally then formally.

For example, at the grassroots level, informal groups in society adopted specific socio-cognitive paradigms, which eventually became SCIs for sustainability on wider scale and structural levels in the RIS. This meant that innovations and technologies that were tried and tested in these communities, were largely developed first as alternative thought processes. These groups of alternative thinkers, developed various technologies, such as the solar home systems, which eventually became formalized SCIs. This took place through R&D, leading to continuous innovations and wider commercialization, and eventually socio-economic shifts

towards sustainability in the region. Many 'innovations' for sustainability sprouted from the grassroots level in the Styrian region.

The interesting finding here, is that the informal and looser socio-cognitive arrangements, began with experiments in society, most often (but not always) coupled to technological innovations for sustainability. Eventually these niches or experiments started to gain momentum and began to formalize as socio-cognitive institutional structures in the wider RIS: the more informal knowledge and 'experimentation' gradually became more formalized through research programs and support from universities or competence centres. These informal structures were also supported by entrepreneurial ventures to become formal businesses. SCIs for sustainability attracted research co-operation with universities, and funding and often political support from government. These were the most prominent formalizing mechanisms in the RIS of Styria. Each of these elements and mechanisms will be discussed below, along with how SCIs for sustainability developed, leading to socio-economic transitions for sustainability.

SCI and connected elements in the Styrian RIS - In Styria, it took time to build networks and institutions of trust and co-operation between the 3-helix partners: government, industry and academia. The development of SCIs supporting a sustainability-orientation within the RIS took even longer to develop. From the researcher's perspective the Styrian region was at the beginning phase of a wider socio-economic transition. It could not be confirmed at the time of the research, (possibly not for the next 30 years), but some significant evidence of socio-technical transitions for sustainability was apparent due to wider socio-economic shifts.

Isolated SCIs existing in government, academia and in the private sector that did not necessarily see the benefit of connecting to other elements in the RIS – resulted in 'siloed' thinking between organizations and institutions (Academic M 2012). Govt & Int B (2012) suggested that there were some difficulties in bringing the 3-helix partners together. In some cases, it was enforced legally, through the structure of the management organizations of the clusters which had to be triple-helix by law. However, it also happened informally through events and workshops and through creating joint value in projects (Govt & Int C 2012). It was evident from the findings that often informal SCIs changed to formalized SCIs which eventually led to accepted and uncontested institutions in society supporting sustainability.

Perceptions, values, norms and associated behaviours as informal SCIs have changed over the last few decades in the Styrian RIS. Formal SCIs became far stronger as a result of research, training and knowledge production and the role of cooperation between elements. There were improved connections between universities and the private sector strongly aided by the role of intermediaries. These intermediaries, in many cases, also pushed industry and academia to shift their mind-sets (SCIs), and eventually also their research towards sustainability, further formalizing SCIs.

The various urban centres in the Styrian region were also important spaces for interaction between RIS elements. Govt & Int E (2012) suggested: 'Cities are 'melting pots' for innovation – it's because of the network you have there. These networks influence each other in a certain direction'. The structuring of formal SCIs – i.e. knowledge in universities and R&D in firms - was enforced by informal SCIs supporting new directions for innovation towards sustainability. This mostly took place in the urban spaces of Styria, like Graz.

The process of formation of SCIs within the RIS was not linear. This was evident in the discussions with academia about how SCIs for sustainability became formalized within universities. Academic L & P (2012) suggested that it was in fact societal influence on universities that led to more formalized teaching, learning and research programmes for sustainability in universities because of a demand for it from students. This societal pressure led to the first teaching and learning programmes in environmental science at Karl Franzens University in Graz. In the interaction between teachers, researchers and students, the SCI for sustainability became more and more formalized in the RIS. This was because – 'these graduates now sit in industry positions and are influencing industry in a positive way towards sustainability' (Academic L 2012). Another perspective from a vice-rector is that universities needed to become more 'socially responsive':

> Ja you see universities in Austria have always been told that, or for a long time, been told that they are doing their job in an ivory tower and that we are not thinking, or not thinking enough about social needs and the society and we really try to fix this and doing effectively. We have a faculty, the only task of which is to go outside and to bring people from outside into the university to get into contact with the university
>
> (Academic N 2012)

In both cases, there were societal pressures on universities to transform the formalized SCIs within their internal structures. In turn, universities assisted in formalizing the SCIs for

sustainability, having a direct impact on RIS through graduates but also through research for sustainability (Academic R 2012).

The strong social activist and environmental movement in the '80s was an informal SCI. However, it transferred to and became embedded in the minds of entrepreneurs and innovators at the grassroots level. It eventually became formalized through partnerships and connections in the RIS. However, there were two separate socio-cognitive institutional groups in the private sector: those of entrepreneurs and innovators at the grassroots level who spearheaded change for sustainability; and those at the corporate level who changed their perceptions because they were forced to through legislation. Eventually these two 'groupings', coupled to increasing university influence and continued societal pressures, formalized SCIs in the RIS and in society. This led to eco-world as a cluster that embodies formalized SCIs for sustainability within the RIS. See endnote for further details on 'Eco-world'.[c]

A major shift in SCIs in the private sector was the strong enforcement of collaboration through the various cluster policies and initiatives in the RIS. As suggested by Firm S (2012): *'co-operative working is one of the biggest improvements we have done in Styria so we have learned from each other. Science from industry and industry from science.'* The technology roundtables for Eco-world brought together 3-helix players to discuss sustainability issues and opportunities. It was a conceptual and physical space where SCIs were both shaped and formalized in the RIS for sustainability (Govt & Int B 2012).

This section has illustrated the extent to which the various elements in the RIS combined to spread new SCIs. New, informal SCIs for sustainability were often in strong isolation before they combined with other RIS elements to formalize and diffuse. However, it was firms that were the innovators, enabling transitions to more sustainable socio-economic pathways.

SCI in Firms – The private sector and firms played a major role in the shift of the RIS towards a sustainability-orientation. The private sector, consisting of entrepreneurs, SMME's and corporates were the actual innovators, but they were beneficiaries of knowledge from universities and support from government. In the discussion about what shifted the mind-sets or cognitive frameworks of leaders in the private sector there were several responses. It was found that the sustainability agenda was often at odds with the core mandate of business models in their view, because their primary role was to make profit (Academic J & K 2012).

However, socio-cognitive paradigms of individuals and groups did shift, and eventually formed formal institutions to support sustainability thinking i.e. sustainability-oriented SCIs in the RIS. According to Govt & Int A (2012) society and firms in fact wanted to change, they generally believed in the concept of 'protecting the environment' and later the concept of 'sustainable development'. It was clear that the environmental movement sparked bottom-up entrepreneurial movements for sustainability that eventually resulted in several medium sized companies now forming part of eco-world. Larger companies, although a lot slower to shift, once they began to do so in fact provided a lot of momentum and expertise in moving the RIS towards a sustainability-orientation.

There was almost a clear shifting of the goalposts towards sustainability within the old industrial structures and larger firms as well. Govt & Int H (2012) put it this way:

> …talking about green technology, one has to say that green technology is not something entirely new, growing out of a new garden. It's coming out of the technology of the so to say, old industry [structures]. When you look, where are the most efficient and best deliverers of green technology? These are these old companies like Andritz.

However, larger firms, found it more difficult to shift because of their lock-in, and the greater financial risks involved in changing business models towards sustainability. Academic Q (2012) noted: *'the big changes will be made in all cases by start-ups because you don't learn new tricks to old dogs'*. Despite this, there was evidence of the larger firms moving towards a sustainability-orientation (Academic P 2012). In general, it was the smaller firms that came up with the more radical innovations, eventually constituting all the new firms making up the eco-world cluster. The smaller firms and entrepreneurs were either sustainability-oriented from the start or they shifted in this direction more easily than the larger ones. According to Firm S (2012), industry were a very powerful force in the Styrian landscapeas the primary drivers of sustainability in the region. Firms were the ones who innovated, or adopted new technologies and new business models to implement sustainability. These alternative business models were a response to changed SCIs in the RIS, and sustainability was often viewed as opportunity. However, in most cases the firms made use of the wider RIS elements to enable these shifts.

SCIs of firm actors (both large and small) were, however, definitely influenced in their shifts and supported by the wider set of actors and elements of the RIS including universities and government. The growth of the eco-world cluster stemmed from like-minded individuals,

employees and firm CEO's. They at first shared informal SCIs which eventually became formalized and institutionally taken up into the RIS. Below is a description of how SCIs become more formal in the cluster network of Eco-world:

> One important thing is that they see the sense of the network is coming closer, learning from each other and also to have success. They realise that when they are in the network, they do not only profit from some services we offer. They profit because we promote the whole province of Styria, as location of Green Tech Valley, you know. Our goal is to be recognised worldwide as the Green Tech Valley, like Silicon Valley, for example. The Green Tech Valley..., so each company who is in this network, yes, would be promoted by Eco World Styria and they profit from connections we offer by knowing the CEO of different branches. We are also involving branches, industrial branches which are not yet doing Clean Technologies, or working in Clean Technologies, but we offer new business models, for example. New youth for gaining business, yes, what do companies want, they want business, but they want also to do something good for the environment.

The availability of alternative SCIs was one thing, but the availability of resources within the RIS to enable socio-economic transitions was quite another. It helped to reinforce the SCI of actors in the private sector especially. Eventually the resources required for larger scale socio-economic and socio-technical transitions for sustainability were developed within the RIS itself, as the cluster of firms in Eco-world, and associated institutional support from the other elements and mechanisms in the RIS. One respondent, Academic R (2012), provided the perspective that Eco-world represented an institutional structure within which firms and research organizations and other RIS elements that wanted to shift towards sustainability could operate. Thus Eco-world represented an alternative institutional framework for socio-economic activity, as compared to more mainstream, purely profit-driven structures. An example is provided in endnote.[d]

However, in several cases 'new ways of thinking' on an individual and group level happened in isolation from wider SCIs supporting a sustainability orientation. This proves that the role of individuals as leaders, pioneers and innovators in society was also an extremely powerful change mechanism in the Styrian RIS.

Sub-section Conclusion - As discussed throughout this chapter, informal and then formal SCIs gradually began to form more generalized institutions transforming the institutional structure of the Styrian RIS. These institutional structures eventually affected the more tangible elements in the RIS: via research support from universities, through clustering of like-minded entrepreneurs at the grassroots level, and through clustering of established firms

in Eco-world. Part of the tangible restructuring to support sustainability-oriented innovation in the RIS was of knowledge infrastructures. In Styria, over time, several formal research programmes to support sustainability were instituted within the five universities (Govt & Int A & B 2012; Academic H 2012). However, there were also considerable social and financial investments to support intermediaries that actively promoted sustainability. The universities undeniably played a major role in the formation of formal sustainability-oriented SCIs in the RIS. However, both the physical and institutional infrastructure, including competence centres and research institutes, was supported by government grants and policies that favoured sustainability-oriented establishments in the RIS. These knowledge infrastructures assisted in further developing SCIs for sustainability especially in the RIS networks (Govt & Int G 2012). What was also clear from the respondents was that there was considerable re-structuring of existing research and knowledge generation capacity towards sustainability (Academic P, R & N 2012; Firm S 2012). In more recent years, it was also evident that the 3-helix and elements of RIS were far more integrated and goal-oriented in finding innovative solutions for sustainability. This was evident from the number of joint projects and events, and the co-development of solutions.

6.9.1.2 SCI and mechanisms of the Styrian RIS

As described above, the formal and informal SCI, supporting a sustainability-orientation, eventually became embedded in the RIS. Embeddedness, as described in the literature, refers to a cultural and institutional 'thickness' that supports the orientation of development and of innovation in a region. The notion of 'embeddedness' is tied to the regional and locational complexities of culture and place. The role of SCIs within the embeddedness of the RIS was something that could be referred to in some of the examples and narratives provided by respondents. Embeddedness included not only the particular values that are inherent in Austrian society generally, but even those which were particular to and unique in the Styrian region, the city of Graz and surrounding towns. One respondent referred to the Styrian region as being the centre of knowledge generation during the Hapsburg Empire, a history which influenced the embeddedness of knowledge positively as an institution in the region (Govt & Int H 2012). Firm W (2012), for instance, suggested that the behaviour of a firm is influenced by its immediate environment, as an individual may be influenced by his or her family. In fact, it went so far as to suggest that family values play a role in the SCIs that are developed in society, and to ask how this may influence decision-making at the firm level. However,

this respondent also suggested that firms can influence society and their SCIs. He used the example of open-innovation:

> We are doing open innovation, in the best way, with this work and open innovation, we have good people, we have people with some, they are open minded, they are going to the company not switching off their brain, but thinking a lot how to improve the machines we already have and it's just a small impact to get ideas from the people. This is one thing, but the other thing is to have outside partners to get ideas. So for example it's this organisation Ecoworld Styria, we are sitting together once a year minimum where we have strategy meeting with Ecoworld Styria and there are sitting people from I don't know, water treatment, and house building, safe construction and wood processing, glass recycling, Binder … a lot of different types of industry are coming together and discussing problems or new ways to approach the green technology industry or whatever.
>
> (Firm W 2012)

The practice of 'open-innovation' between firms helps build networks in the eco-world cluster. It also builds uniqueness through the SCIs of actors in these networks, as an embeddedness in the RIS supporting sustainability. Embeddedness also includes the idea of close co-operation within the 3-helix, which slowly begins to transform the SCIs of actors in each sphere of government, academia and the private sector (Govt & Int A, F 2012).

The embeddedness of 'outmoded' SCIs was of concern to one respondent: Academic P (2012) suggested that the idea of incremental innovation was strongly embedded within the RIS, and difficult to change. Incremental innovation or 'improvement' in his view is an issue for sustainability as it impedes radical innovation. Often, the spaces 'in-between' the elements of an RIS is where the mechanism of RIS is at play. It was also found in discussions with respondents that mechanisms like embeddedness play a vital role in transferring the SCIs of sustainability between the elements. The role of intermediaries was once again of paramount importance in the transfer of SCIs (Govt & Int E & F 2012).

Knowledge production and financing are also RIS mechanisms that are a product of interaction between the elements producing the knowledge. In knowledge production, for example, intermediaries built connections between universities and research institutions that traditionally did not collaborate (Govt & Int B 2012). For example, 'Eco-world' assisted in bringing research agendas together between the universities and the private sector. They, for example, commissioned research on behalf of Eco-world's members that could be beneficial to them or to the regional economy in general (Govt & Int C &D 2012). Often this

commissioned research had to do with sustainability-oriented topics. Several examples of such research interaction mechanisms are expanded in an endnote.[e]

Finance was a vital mechanism that was not only influenced by SCIs for sustainability, but influenced SCIs within the RIS. Finance was one of the most powerful drivers of innovation in the region. However, the approach to structuring and financing intermediaries in a visionary way also led to strong co-operation in the RIS. For example Eco-world and most other intermediaries received funding from government to begin with. However, their board of directors and eventual ownership needed to be a 3-helix structure. Often the financial and regulatory conditions were set-up in this way to ensure collaboration between the elements of the RIS (Govt & Int A, B, D 2012). The SFG was the primary finance intermediary in the modern RIS in Styria. It assisted in providing state funds for other intermediaries, like Eco-world. The SFG also supported industry directly by supplying government grants directly to industry:

> SFG is, we say a business promotion agency, we are giving grants to our companies in Styria, so last year we gave about 86 million euro's in grants. So we have the monetary sector and as well the non-monetary sector that we are organising the business events, doing a lot of networking.
>
> (Govt & Int F 2012)

Interesting points were raised by several respondents about the system of financing of the RIS. Some respondents suggested that there needs to be a finer balance between funding research from industry and from state or public funds (Govt & Int F, G, H & J 2012). The system of financing may influence the direction of research. It may lock the RIS into a cycle of knowledge production that continues to be incremental. This would be an issue for achieving sustainability transitions through ISs, because, as expressed in the ST literature, systems need to shift by a factor of ten. Incremental innovation won't provide that. For more details on financing mechanisms see endnote.[f]

The firm respondents make it clear that financing is vitally important for sustainability. This is primarily to reduce the 'risk profile' of the RIS in investing in sustainability-oriented innovations (Firm S, W, X 2012). According to Firm S (2012), 'green financing' is required to shift the business models of firms enabling them to implement more sustainable solutions. Finance is a powerful driver of shifting SCIs in the RIS in a sustainable direction.

Sub-section conclusion- Financing and knowledge development are ultimately the two most important mechanisms in the RIS, and are both able to shift the direction of SCIs. This places a premium on developing knowledge for sustainability at universities, schools etc.

6.9.1.3 SCI and proximities in the Styrian RIS

As discussed in the literature, proximities of actors and elements within the RIS not only refer to geographic proximity. Assessing the alternative forms and definitions of proximity in the content analysis of the data reveals an interesting narrative about the role of SCIs in them, and between them. 'Proximities' provide an excellent lens with which to unbundle the complexities around socio-spatial and socio-structural relationships and effects. This is unpacked in this section, but from a viewpoint of answering how SCIs develop, informally and formally, as they are embedded in RIS structures, thereby affecting the socio-economic mainstream towards a sustainability orientation.

SCI and cognitive proximities – The formal socio-cognitive institutions of knowledge and training relate to the concept of 'cognitive' proximity as discussed in the literature. In the findings, there are several examples of cognitive proximity, and in some cases cognitive distance, between elements in the RIS.

Govt & Int C (2012) spoke about special education for sustainability that was instilled in schools, colleges and universities and society, as an intervention that effectively brought sustainability into focus in the minds of society:

> We had some very special education [for sustainability], because, even the politicians recognise that it has to be done and we've done it very early with some programmes, even in the city of Graz and all the way in the province of Styria, fostering measures to become sustainable and also to be aware of sustainable environmental measures.

This kind of education brought the various stakeholders and actors in the RIS to a common point of understanding about sustainability issues, early on in Styria. For example recycling was taught at school, at the same time that the government was trying to instil this in society. The children from school passed their knowledge on to parents, who took this to their workplace (Govt & Int I 2012). This education built SCIs around sustainability issues, and brought the cognitive proximity of the subject of sustainability closer so that it was not a foreign concept to most citizens.

Again intermediaries were often the ones who promoted closer cognitive proximity for sustainability in the RIS. For example Eco-world and SFG promoted technology round-tables

and 'innovation clubs' on sustainability topics that included universities, innovators and government (Govt & Int F 2012). (See endnote for an example given by Climate Change Graz).[g]

As was to be expected, in discussion with the respondents there were also instances of cognitive distance in the RIS. These were most notably between specialized industries and the wider set of actors in the RIS who did not have the knowledge to understand their needs. Industry in most cases understand their own needs, but in some cases there is a gap between this understanding and that of government and universities or SCIs. Related to this, Govt & Int G (2012) explained that there are different levels of understanding in society. Genuine sustainability may need to be supported by experts rather than the 'general' or the 'average' societal SCI. This is why different levels or pockets of SCI at a micro level may be so important, because they can be made up of expert leadership – and then through time become more popular as society learns more.

In other instances, there were isolated innovation and entrepreneurial groups in society, similar to what is described above. However, these groups usually also surrounded some kind of technology or innovative solution that they were interested in developing or pushing to market. The cognitive proximities within these groups were very close, and the knowledge about their innovation was kept isolated in the beginning in some instances, and in other instances not. An example is the development of bio-fuels that took place in close cognitive proximity between a university professor and some entrepreneurs. For more on this and other examples, please visit endnote.[h]

Cognitive proximities, already mentioned from an industry and entrepreneurial perspective, were in many cases isolated within institutional and organizational silos. The problem with many RISs including the Styrian RIS, was the cognitive distance between researchers or academia, industry and government. Universities have a special function in trying to build cognitive proximities within society in general, but often their efforts are often not enough (Academic N, H, Q 2012). Facilitatory interventions from government are often needed to ensure that the 3-helix stakeholders are brought into closer cognitive proximity. The influence of intermediary organizations can be particularly effective in bringing actors from the RIS closer together to enhance cognitive proximities when they are distant. In Styria, this was often done through social events, and professional networking events, workshops and conferences all of which included the 3-helix stakeholders of the RIS. Thus social and

cognitive proximity went hand in hand (Academic Q 2012). Cognitive proximity was a vital contributor not only to the effective functioning of the RIS, but also for diffusing knowledge about sustainability, and understanding the potential solutions that existed in the RIS. Finally, media also played a fundamental role in educating and building cognitive proximity for sustainability and environmental issues in Styria over the years.

Organizational proximity – Organizational proximity between firms became closer and closer over the three decades to 2010 in the Styrian RIS. This could be attributed to the efforts by the regional-level government to promote interactions between firms, which resulted in a highly successful cluster policy.

The findings of respondents from the group *'*Govt & Int*'* suggested that closer organizational proximity, in fact led to growth in the Eco-world cluster. Government and intermediaries played an important role in stimulating organizational proximities through incentive structures, events and various programmes (Govt & Int C & F 2012). As more and more firms began to better understand the notion of sustainability, they also began to see the opportunities for profitable innovation in the sustainability direction (Govt & Int B 2012). In the co-operation between firms, and universities for that matter, there was a strong push for 'open' innovation, especially among smaller firms. As suggested by Govt & Int D (2012):

> I think we can share all our companies' and research organisations' best practice, for example, how companies could be more successful if they use this co-operation, if they co-operate with other companies that are research organisations and if we show them best practice cases, they can create value. They are more competitive and so there is a certain need for the competitors to be also very co-operative and to create value and to get to the next stage, or to be more competitive.

Academia, responded to the notion of organizational proximity in a similar way, suggesting that there was a gradual build-up of business and organizational networks in Styria. Besides the government policy of clustering (Academic Q 2012), incentives existed for companies to co-compete to service larger firms in the region (Academic M 2012). Eco & co was mentioned as the start of this for the Eco-world cluster, which was also initiated by some big events (Academic L 2012). Initially it failed because the organizational proximity and exchange of actual knowledge and information between firms was distant – the network was too loose (Academic O 2012). This changed however, with the tightening of organizational proximities in the formation of Eco-world. The respondents from firms reinforced these findings and were positive about the concepts of clustering and open-innovation. See endnote for examples.[i]

SCI and spatial proximities – Spatial proximity of actors in the RIS was regarded as an important factor in the shaping of SCIs in society. The region of Styria was characterized by only one medium sized city of Graz, and several smaller towns surrounding it. The City of Graz, was certainly the central hub of economic and innovation activity, being home to four of the five universities in the Styrian state. The urban space of Graz was also seen as a 'melting-pot' for innovation and sustainability thinking. Evidence of this, was that the city had recently won the 'greenest' city or town of Austria award (Academic P 2012). The city of Graz, as many cities do, provided close geographic proximity to the large knowledge resources of the universities, and to research institutes which strongly promoted and reinforced sustainability thinking. Students, teachers and researchers were in close spatial proximity, and this had a marked effect on the SCIs for sustainability in the city. An interesting story of spatial proximities of RIS actors that preceded the strong SCIs for sustainability in Graz was that of a small neighbouring town called Gleisdorf. In this town, there was a strong social movement towards sustainability, which resulted in many companies also being sustainability-oriented, or locating there (See endnote[j] for details).

Eco-world, on the other hand was thus not a spatially-bound cluster in one city or town, it was spread out between the city of Graz and several smaller towns in the region. However, there were close proximities between several smaller companies within the outlying towns and areas. Firm X (2012) is one example of this. In partnership with another firm it created a small 'campus' environment for bio-diesel and engineering services for clean-tech. Spatial proximity was important, and had an effect on the transfer of knowledge between universities and society.

Many of the businesses however, were in closer proximity to each other, rather than to the universities. For firms in the RIS, other forms of proximity, like cognitive and organizational proximity, were possibly regarded as more important for building SCIs for sustainability than spatial proximity was. This was an unexpected and interesting finding from the researcher's viewpoint, who thought that spatial proximity would play a bigger role. However, in terms of building SCIs in general in society spatial proximity was extremely important as this went hand in hand with social proximities.

SCIs and social proximity – Social proximity is about the number of friendships, kinships and levels of trust within the RIS. Both from the responses of interviewees and from the experience of the researcher it is clear that social proximities are a strong point in Styria.

Social proximities like spatial proximities often go together, and communities that are closely spatially connected are also usually closely socially connected. Again the town of Gleisdorf and many other smaller towns provided examples where close social proximities shaping SCIs for sustainability were prevalent (Govt & Int E 2012). More practically, the solar home movements in the '80s were classic examples of close social and spatial proximities. The trend of putting up solar PV on the roof of your home was reinforced due to close social and spatial proximities in the so-called *neighbourhood effect*. Often smaller communities and neighbours would not only copy each other, but come together to assist each other in learning about and installing solar PV themselves in the communities (Govt & Int A 2012; Academic L & Q 2012). This was a classic example of *localized learning* for sustainability through social proximities. For additional examples please visit endnotes.[k]

SCIs and institutional proximities – Institutional proximities can be understood in two ways. The first is the closeness or distance between various organizational institutions that make up the elements in the RIS. The other form of institutional proximity refers to institutions within society – which includes SCIs.

Findings on the first form of institutional proximity between elements have already been loosely referred to throughout. In the past, institutions were often distant from each other and operated in traditional siloes. In other words, government, academia and industry did not have effective proximities or close ties of co-operation. The reason for this is that the prevailing SCIs supported organizational independence, with each institution having its own function in society. This SCI, however, evolved over time, as systemic thinking became more prevalent and the notions of co-operation, clustering and systems of innovation were adopted. More recently, the institutional proximity between the elements in the RIS could be described as close, as confirmed by most of the respondents (Govt & Int E, F & G; Academics K, L & M; Firm W).

Section conclusion - SCIs for sustainability were initially not only cognitively distant but also institutionally distant. Over time, the SCIs for general cooperation around sustainability and specific innovation for sustainability grew within the RIS. Eco & Co, and Eco-Profit were two examples where looser societal SCIs became more formalized through inclusion in more institutionally rigid structures like the RIS (Academic O 2012). Spatial proximity was important, but it was the social proximities and connections and other non-spatial proximities (institutional, cognitive, organization) which were in fact the most important. Various inputs

are given below into what affected SCIs in the region, through time and in terms of their quality.

6.10 SCIs and historical perspectives

Although the history of the socio-economic transformation in Styria has been described above, some additional and important historical events follow on from this. The concepts of both innovation and sustainability were relatively new in Austrian society in the 1980's. According to the respondents, although there were some innovative activities, there was a low level of innovation immediately after the privatization of the SOEs. This, however, changed quite rapidly, and innovation became more and more of a prominent feature of the Styrian region. In parallel, the environmental movement was prominent at about the same time as the Styrian economic crisis. Along with the shift in economic structure from M2 type to M1 type sectors, there was considerable incentive in the SCIs of smaller and more innovative firms to find solutions for environmental concerns. These socio-economic structural shifts simultaneously shifted SCIs and in some cases SCIs shifted the direction of development in a more sustainable direction. However, the SCIs for sustainability remained a minority within the wider socio-cognitive institutional structures in Styria during the period of socio-economic restructuring.

Since then, there has been a gradual development of the economy in a sustainability direction over the last thirty years in Styria, and it continues to strengthen. It is slowly influencing socio-technical transitions for sustainability in the region.

> The story about Eco-world is not about 5 years of cluster businesses: it's about 30 years of social development, a strong civil society is one ingredient, strong R&D phase which is evolved, industrial competence with the major change from heavy industries into something new to have jobs and the move forward to technology.
>
> (Govt & Int B 2012)

According to Govt & Int C (2012), the move towards sustainability thinking began with the influence of the media. They had a strong focus on green issues that society responded to in the region. Another external driver of sustainability thinking in the region, according to Govt & Int H (2012), was the need to prove that Austria was ahead of the world in standards and thinking about progressive concepts like sustainability. This is described well by Academic K (2012):

> I mean the shift is not an on-going process as I said, there was a shift in the '70s, '80s and then was the phase where Austria and Austrians, they're really proud that we are one of the cleanest countries on international ratings, and Austria was always proud to be not only wealthy but also very clean, environmentally friendly.

At a later stage, Austria joined the international community discussions in Rio de Janeiro in 1992 about sustainability (Firm T 2012). After this, there was some controversy about the international Agenda21 provisions, and Austria's own concept for sustainability called 'Ekosoziale marktwirtschaft' or ESM. This political concept was in fact developed in Styria according to Academics Q & R (2012). The Styrians thought they did not need to follow Agenda21 as they were already were doing the same thing in their own way (Firm T 2012). At a later stage, Styrians did in fact adopt Agenda21 and other sustainability principles, regulations and standards – the latest of which were provided by the EU. For more details of how Austria's entry into the EU affected it, please view endnotes.[1]

Innovation in Styria was certainly not only developed as an internal dynamic, and had many influences from outside. These included the many events and global shocks such as the oil crises in the 70's. They also included seeking new markets for growth in the Middle-East and Eastern Europe as has been discussed above. However, endogenous markets did play a significant role, and could also be the reason for strong local networks in the RIS. Academic R (2012) suggested that during this phase there was also a shift from linear thinking about innovation towards systemic understanding:

> At that time, it was a very linear approach. The innovation systems approach and the nonlinear concept of innovation is rather recent. It was only, I would say, in 1993, 1994 that both regional and national government first conceived that there is something different from the linear approach

Another important driver of socio-economic transitions to sustainability was visions about the future from society, politicians, and entrepreneurs amongst others. They were not connected to the past but the future.

6.10.1 SCI and visions

Visions for development in Styria were another important reflection on the qualities and direction of SCIs in the region. In discussing visions with respondents it was clear that there was a strong push for the notion of sustainability.

From the group 'Govt & Int' there was a lot of discussion about old visions and future visions for sustainability. For example the referendum to halt nuclear power was seen as a vision that

had been achieved. This vision ushered in opportunities for renewable energy generation as an alternative and had a dramatic effect on the RIS to shift in a sustainability direction. Govt & Int B, C & D (2012), all representing Eco-world, were very clear about the visions for sustainability in the recent past. They suggested that there was a very strong vision for sustainability in the Styria region and this had a direct impact on the direction of innovation and the economy. Eco-world for instance had a powerful branding and vision for the future of Styria as the 'green-tech valley' which was to be supported by a 'green-tech' strategy. Climate Change Graz (CCG), another intermediary also had a clear vision about the implementation of climate change policy for the region (Govt & Int E 2012). Interestingly, it was suggested that during the 80's the vision was more about an ecological movement than a sustainability movement Govt & Int G (2012). The general Styrian perception during the 2000s was that ecological efficiencies and standards had been achieved and thus there was no need to enhance efforts for innovation in this field, but to just continue on the current path. This was surprising to the researcher. The more recently focus has been on social aspects like job creation and financial security, especially in the wake of the financial crisis. Another interesting concept representing a vision is the smart cities concept that was quite strongly being driven by leaders in society in Graz, and Leoben a nearby university town (Govt & Int J 2012).

The Vice-rector of KFU, provided an interesting social perspective on visions for the future, suggesting that SCIs were changing in the general societal domain. They can be seen as one of the main reasons for steering towards good practices for sustainability. The consciousness around organic food, its health benefits and taste benefits was used as an example. In a way this can be translated into a vision for society – a progress in terms of health and wellbeing. This is a goal for a societal transition in this respondent's view (Academic N 2012). For another example see endnote.[m] Lastly, the view by 'Firms' was interesting as well, as they provided almost the view of entrepreneurs. They suggested that it was 'visionaries' like entrepreneurs who had the ability to see into the future, and find gaps and needs in society that helped to shape and change the system of RIS (Firm T,U, X 2012). Several examples of these entrepreneurial ventures and successes have already been discussed above.

6.10.2 Rigid SCIs in the Styrian RIS

However, as with visions for sustainability there were also visions and social, cultural, institutional and technological structures in society that represented lock-in and a reluctance

to change. On the 'social front' this hampered the spread of SCIs for sustainability in some cases, and with it, the ability to influence RIS. But it also went the other way, and stubborn groups at grassroots level also were host to strong SCIs for sustainability that would grow in strength.

A good example, mentioned previously, of SCIs that may oppose the required thinking within innovation to achieve sustainability, is that of the thinking supporting incremental improvements and innovation. Academic P 2012 says, 'ja, improvement is not risky, innovations are risky; if you go to the manager and say we want to be better, they say – oh fine. If you say to the manager I want to be different, they say – ooh, I'm afraid of being different.' Hence changed viewpoints and SCI, were in some cases seen negatively and several SCIs especially in larger industrial structures were programmed to avoid risks. Another example is that of competing SCIs between large firms and smaller firms. Smaller firms often come with new SCIs, and new technological alternatives having the potential to be disruptive through their innovations to larger firms (and their competitiveness). The innovation of the wood fuel heating systems is a good example, seen as a threat by larger German energy companies. These companies thus make it extremely difficult for the smaller companies with viable alternatives to enter the market. For example they ensure that they lobby government to keep legislation in place that favours larger incumbent energy producers, even though they are unsustainable (Firm V 2012).

6.10.3 Qualities of SCI in the Styrian RIS

There are certain values present in shifting society towards sustainability. For example the monk's cloister, or monastery building, which is a heritage site and had recently showcased solar power on the walls. This was symbolic of change in the society and showed a consciousness shift in the society, and the qualities of the SCI (Govt & Int 2012). For this to take place however, old and rigid SCI structures were broken down and replaced by new SCI. The qualities of SCIs in the Styrian RIS, changed in some instances because of visionary leadership. One of the respondents quoted an influential politician of the past, who said: 'If you have a problem, you must try to make a job out of it!' which reflected a certain quality in the SCI of actors in the RIS (Govt & Int I 2012). In other instances it required, shocks, events and negative pressures to their personal interests or way of life that changed 'mind-sets' or SCIs. For example,

> I think a very important event was in Graz, for example the situation of the air, the local air quality because at the beginning of the 80s we have a big problem with smog in Graz, especially in winter, and then the people and the politicians think about measures, what can we do, can we reduce the mobility, we can insulate the buildings, we can change the energy systems from coal and oil to renewable, to district heating systems and so on, that was one click in the brain, and it changed.
>
> (Govt & Int E 2012)

For some, global issues like climate change were also a driver of altered perceptions, attitudes and behaviours (Govt & Int E 2012). Others believed these issues were not influencing the qualities of SCIs in the Styrian RIS that much (Govt & Int G 2012). This respondent amongst others was more sceptical about the reasons for change of SCIs in a sustainability direction. Their view was that society does not change perceptions by itself: there is a strong need for either a push, like a crisis, or incentives like new markets or government grants etc. SCIs although they may be 'wanting' in a certain direction are heavily influenced by financial incentives. But in society also, drastic changes often can't take place, because politicians would lose their power. They need to keep society happy, and drastic changes would prevent this (Govt & Int G, J & H 2012).

Several academics provide the rounded perspective that education, through teaching, learning and researching provides the greatest hope for changing SCIs both informally and formally. Academic K (2012) suggested that whilst universities can be 'role models' for sustainable practice in society, the education for this should in fact start a lot earlier at the elementary school level.

The reference to the general SCIs of Austrians and society in general, in the findings, suggested strong and favourable SCIs for sustainability. However, it is also the RIS itself that influences society, through discovery and new research taking place within the RIS. This statement summarizes the notion that the qualities of SCIs in Austria were/are favourable to sustainable development:

> It's because we have a general awareness in Austria, that environment protection is a high value for us because Austrians want somehow to do the right things you know and are aware that doing the right things it also belongs somehow to the question, how do we deal with the environment and maybe it's a kind of even, not using the term sustainable development but thinking about questions that are in our minds that's definitely related to sustainable development. And I think this enables industry and this enables government to make those steps and then move society a little bit and this is certainly reinforcing
>
> (Academic L 2012).

Some respondents however, felt that industry did not see the concept of sustainability as favourable. Rather it was something of a duty (Academic P 2012). However, after several events and extreme pressures from society and government legislation, industry not only changed their SCIs, they became in some cases strong drivers of sustainability in the region. One firm respondent (Firm S 2012), made an interesting comment about how his SCI shifted in a sustainability direction. He suggested it was a 'consciousness shift' after experiencing the change in the pollution in the rivers:

> But I think there were some obvious experience for the Styrians, especially Graz for the people here, we have a big river, the river 'Mur' maybe you know. In the late '70s, the paper production companies in the north of France have been polluted this river enormous, there was no life in it, really no life. But after some years, and through improved qualities, they changed the production processes and the river became cleaner and today it's really living water, so there are fish in it, the fauna and flora is really alive again and it was just small single steps.

Other Firm respondents (Firm T, U & W 2012) reinforced the notion that the qualities of SCIs for sustainability in society began to filter into the practices of industry. Once the idea of sustainability began within these firms, it spread as well – 'it was like a seed in the ground and many companies switched over to this green technology field' (Firm W 2012).

Section conclusion – Socio-cognitive institutions were found to be a major influence in the direction RIS took - towards a sustainability-orientation or otherwise. Furthermore, SCIs were shaped by the various elements and mechanisms of the RIS itself. In one view it was leadership from the bottom-up that led to extended informal SCIs for sustainability becoming formalized within the RIS. However, the mechanisms of RIS, like financing and knowledge development played a major role in shaping SCIs, which led to decisions and influences that were sustainability-oriented. In turn this led to socio-economic transformations to sustainability. Socio-technical transitions mostly took place as a result of individual grassroots entrepreneurial leadership – with the strong support of RIS elements and mechanisms.

6.11 SCIs influence of the Styrian RIS, and socio-economic pathways of development for sustainability

The primary purpose of this section is to provide evidence for answering the research sub-question 2b: *To what extent are socio-cognitive institutions a determining factor for sustainability-oriented innovation systems resulting in pathways for socio-economic transitions?*

It would certainly be naïve to suggest that SCIs are the only factor that leads to pathways for sustainability in development. More of a question is how SCIs guide the decision-making of actors in the RIS when they are faced with choices, one more sustainability-oriented that the other. SCIs are a societal framework for guiding the decision-making of individuals and groups in the RIS. The research sub-question seeks to find evidence of this, and describe to what extent SCIs guide the actions of RIS actors towards sustainability. This is done through discussing how SCIs are the primary influence, how they become influenced, and finally what other influences may be there be besides SCIs. It is a brief summary of the findings, because the intricacies of how SCIs affect RIS have been dealt with above in detail already.

6.11.1 SCI as a primary influence on directing RIS

Outlined here are the suggestions from respondents that SCIs influence the trajectory of the RIS. How they do so is briefly discussed here. What was found is that in any situation there are several different SCIs that compete in many ways but also shift and change through time. These SCIs may also exist at different structural levels, they may be formalized, and they may be spatially-based. This is the topic for the research sub-question in the next chapter. Bearing this in mind, Govt & Int A (2012) refers to the development of SCIs that began as associated cognitive frameworks within smaller groups in communities. These communities in some instances found resistance to their ideas and 'movement,' but later were supported by more formalized RIS structures and politicians. With the growth and strengthening of their SCIs' which were strongly sustainability-oriented there was a gradual influence and shift in the wider SCIs of the 'mainstream' which were not necessarily sustainability-oriented.

Govt & Int C (2012) spoke about how the more political concept of ecological modernization, was not enough to achieve sustainability. This was seen as one form of globally relevant SCI, but sustainability would require a more radical change in SCIs to include behaviour changes as well. According to Govt & Int E (2012) SCIs may also be influenced quite rapidly on a large scale as well, like the nuclear and environmental protection events against nuclear power. It was said: 'we changed the energy systems from coal and oil to renewable, to district heating systems and so on. That was one click in the brain, and it changed' (Govt & Int E 2012).

The influence of SCIs on the RIS was always more powerful when it was informed and shaped through research (Govt & Int G & F 2012). Govt & Int H (2012) provides an example of how the decision-making of a firm was influenced through its change of focus to

sustainability, eventually leading to the firm producing products and services that aligned with the socio-cognitive paradigm supporting a sustainability direction in the RIS: 'They became green when they realized part of their capabilities and expertise can be used in the 'green' market' (Govt & Int H 2012).

Academic M (2012) suggested that a big change in 'mentality' took place with the development of clusters. The SCIs for sustainability were reinforced when the Eco-world cluster was established. This also formalized the SCIs into tangible structures and expanded the SCI to include other actors and elements in the RIS. Coupled to this, was the enhanced research and academic programmes being offered by universities in the RIS for sustainability. This further formalized SCIs for sustainability in the RIS (Academic R 2012). The direction and quality of the general SCIs in society also influenced the way in which some firms began to change their thinking internally.

> I think the people around in this area, if you have to realise that this area there was characterized by farming so the people here had some, I don't know the English word, they had connection to nature all the time. So they realised if we destroy everything, I try to assume what they thought, they thought if we are going on this way we will destroy the nature here and so most of this impact came from this region, from the people here and they were convinced we have to do something else.
>
> (Firm W 2012)

From the findings, it was clear that SCIs are a major contributing factor in determining the directions of the RIS, but also in shaping the economy in a sustainable direction. What is discussed below, is whether and how SCIs in an RIS are influenced by its dynamics.

6.11.2 Influence of SCIs in the Styrian RIS

In this sub-section, the aim is to understand how SCIs in the RIS were influenced during the last three decades in Styria. Events and shocks in society and economy are one example that can change SCIs very rapidly, almost instantly. In Styria and Austria there were several events that changed the SCI landscape affecting the RIS: the nuclear referendum and the hydro power protest being the largest local social movements, along with the oil crisis and the economic crisis (Govt & Int A 2012; Academic L 2012).

> There was other political reasons, people said 'no' and the public vote against the power plant – this was a turning point because this was catalyzing the environmental movement, very intensively. And then after this event and the first public awareness about a German coal stations, and emissions and sulphur and nitrogen was a very big issue in the early 80s and this was really discussed in newspapers, people were concerned about this. And you have in the early 80s you had the water power, hydro power plant

> which was then stopped because out of a very huge public protest against this. And this led some very early regulation in certain environmental problems so had some very strict regulation, much earlier than other European countries, such as for air emissions for energy sector.
>
> (Academic O 2012)

The media was suggested as one of the biggest and most influential shapers of public perceptions and SCIs. However, the events published in the media were often sensationalist according to Govt & Int E (2012). The ideas and perceptions associated with the media were often fleeting, and the more rigid SCIs were not affected that much. Govt & Int F (2012) suggested that the Austrian culture, which in a way is a part of the SCIs, shapes itself because of the inherent need to think about the future. This was a deep SCI within the Austrian landscape that permeated actions and decision-making generally in the RIS. Other influences of the RIS, included research and partnerships in the RIS itself between industry and research. This often changed more formal SCIs in the RIS (Academic R 2012). In some cases negatively according to Govt & Int J (2012) because the SCIs became too strongly influenced by mathematics and science, and neglected creativity and the arts. It was implied that this was negative for modern society which required more radical innovations. Another major influence of SCI is expressed through economic factors like markets, incentives and regulations put in place by governments. Funding was a further big driver of SCIs according to Firm U (2012). This Firm and several others also highlighted the need for making a profit in the private sector, as its undeniable primary purpose. Yet, there almost always remained a choice to become more sustainability-oriented. Many of the responses could be generalized, showing that SCIs could be easily influenced and change rapidly, but also, at the other extreme, be very rigid and slow to change.

6.11.3 Other influence of the RIS beyond SCIs

We have suggested that SCIs in society and in the RIS guide individual and group actions and decision-making. These looser arrangements of actions and decisions driven within the framework of SCIs eventually become more structured within the RIS and wider economic practices. This research sub-theme investigates how RIS's may be influenced beyond the realm or frameworks of SCIs.

In exploring this point, it is important to appreciate that SCIs, although continuously being shaped and shaping, do not equate to short-term individual or group thinking. Despite this

understanding, the RIS was often strongly influenced by individuals and groups that did not adhere to any specific SCIs. There are both positive and negative examples of this for sustainability.

The first example, is the leadership shown by individual entrepreneurs, who certainly did not form part of the mainstream SCIs at the time. These individual pioneers challenged the status quo, and went fully against the general or conventional SCIs in the RIS and in society. They were at first criticized because of their alternative thinking. In more recent times they have become regarded as innovation champions who pioneered wide-spread change within the RIS of Styria. Several of the interviewees in the private sector fitted this profile of being innovation champions who collectively began to formalize their own SCIs for sustainability (Firm S, V, X & Y 2012).

On the other hand, there were also leaders in society and in government that prevented or, at least in the Styrian case, tried to prevent sustainability decisions from being taken. This was supposedly in the interests of economic growth, and for financial reasons. Again, the two primary examples of the nuclear referendum and the protest again the hydro power station can be used. One politician was for the power station, and the other against. The winning of the referendum to stop the nuclear power station, was signalled in immediate legislation that banned nuclear power. Although the majority SCIs of society (51%) were against nuclear, it was the actions of government following this, in immediately putting legislation into place that banned nuclear power in Austria that led to an instant shift in the orientation of the RIS. There were suddenly definite opportunities to seek and produce alternative energy sources which sparked opportunities for shifting focus in the RIS. The point to be made here, is that although SCIs supported legislative changes, it was not until the legislation itself changed that the RIS changed its focus and search to alternative energy. It thus required a wider and formalized institutional shift in the RIS before widespread SCI change also took place. Here the RIS had changed first through legislation, and this formalization sparked further changes in the SCIs of actors in the RIS (Govt & Int B, F 2012).

Section Conclusion - From the findings, it is clear that SCIs are a major contributing factor in determining the directions of a RIS. However, SCIs themselves, while shaping the RIS, are also shaped by it. There are multiple external factors that also shape a RIS, like legislative changes or shocks and events. Ultimately SCIs are guided by a RIS. What is evident from the findings is that economic decisions are often taken in a direction that is unsustainable. This is

not because SCIs for sustainability don't exist, but rather because there are competing SCIs in society. The final investigative theme focuses on the dynamics of competing SCIs in different structural and geographic contexts.

6.12 Findings for investigative Theme III

The findings provided below are developed in the context of research sub-question 3: *How do socio-cognitive institutions exist and how are they shaped by various forms of proximities on different structural and scale levels?*

For the findings to be better understood and discussed in a focused way there are a number of aspects relating to SCIs that need to be qualified below. Generalized insights about SCI structurations[34] in society, or 'SCI structures' for short,' are developed here from the case. These insights build on the more theoretical background and distinctions of institutional macro, meso and micro levels and social structures and scalar levels discussed previously in the dissertation. In Appendix D7 Figure 4.7 below, shows the percentage of coded segments comparative to each other. The majority of discussions were centred on how SCIs were shaped at different formal and informal structural levels. Proximities and the quality of SCIs were also a well discussed topic.

The micro level is where loose social groupings of individuals begin to come together and form 'fragile' or 'alternative' SCIs to those existing at the meso and macro levels. Through extending networks and building connections in the RIS, these SCIs slowly begin to take shape as informal institutions. Through their continued association and external legitimization within the RIS element they are able to influence it and begin to shape it at the meso level at the same time formalizing SCIs. The macro level represents deeply embedded SCIs, that are difficult and slow to change. Spatial dimensions as scales between the micro, meso and macro structures also influence the SCIs at these structural levels. They are interconnected, as socio-spatial dynamics. Proximities provide an excellent lens to unpack the complexities of these dynamics, and influences. Thus, at the micro level, there are multiple different SCIs in the process of being developed. What is of interest is the qualities of an SCI. In particular, how do SCIs for sustainability develop, and eventually not only influence but also shape wider SCIs at the meso and macro level. The scalar perspective is provided first,

[34] SCI structures are different to socio-technical structurations and are also a narrower form than conventional social and institutional structures in society.

thereafter the structural perspective. Proximities are used as a lens to bring these findings together.

6.12.1 Socio-cognitive institutions at different scale levels

Findings in the above sections reveal that SCIs were not uniform between different scale levels. The *national, regional* and *local* scale levels hosted different SCIs and were also strongly associated with geographic context. In the findings below these differences are discussed at the different levels but also in parallel.

National scale level - The Austro-Hungarian or Hapsburg Empire was referred to on numerous occasions by respondents. This historical perspective was important, reflecting a strong national identity of 'being Austrian'. With this, came a need for prestige, for being ahead in terms of knowledge development, and so more recently in terms of innovation and economic progress (Govt & Int H 2012; Academic O & L 2012). According to Govt & Int H (2012) this national identity was good in some ways and bad in others. The integration of Austria to become part of the EU played a major role in the shifting of SCIs at the national level (Firm R 2012). The pride and national identity of having a high Austrian standard of environmentalism and 'leading the way' in the EU was not always good for the competitiveness of industry, but it represented a strong 'Austrian mind-set' as a formal SCI. However, the push to lead in these fields also promoted a national effort to innovate and stay ahead of other EU countries. This kind of national SCI may have instilled a readiness or willingness to accept and adopt sustainability as a challenge to stay ahead. For a richer account of this from the findings please go to endnotes. [n]

More recently, according to Academic L (2012), there is no depth of understanding of sustainability at the national level. However, there is an awareness of environmental protection, and its importance in such matters as climate change, recycling and reduction of cars etc. This has an impact on the regional and local levels as well as in terms of shifting SCIs towards a sustainability-orientation. In the last two decades, the Styrian RIS responded well to the national incentive structures to curb environmental issues, leading to transitions in their socio-economic landscape towards sustainability (Academic L 2012). Sustainability, as a concept, according to Academic H (2012) only became popular as a political idea in 1992:

> To my (knowledge), the sustainability issue only came about, I would say, in 1992, 1993. Yes, there was quite some notion of the Brundtland report, and sustainability issues like that at this time and it was also the first time that some Austrian cities were taking part in initiatives on sustainability.

Regional scale level – A major strength and driver of the Styrian RIS, from a regional spatial context was the cluster policy. Govt & Int B (2012) provided a strong opinion about the importance of geographic proximity to accomplish this effective clustering of companies. He suggested that firms need to be accessible to each other in geographic concentration, and also close to research. Furthermore, Styrian society has been something of a 'hot-bed' of sustainability thinking and practice over the last three decades.

Within firms, the cluster policy went hand in hand with open innovation policies in the region. Eco-world used this momentum to advance its strategy to enhance competitiveness in green industries (Govt & Int D 2012; Academic L 2012). CCG, also provided the evidence that knowledge about sustainability, and issues such as climate change were well understood by Styrians in the region. The close regional proximity played an important part in the identity of being Styrian in terms of 'doing good' for climate change and sustainability issues. However, societal willingness did not always translate into actions.As expressed by Govt & Int E (2012): *'the step from knowledge to implementation and change still remained a gap'*.

Eco-world showed tremendous growth as a regional sustainability-oriented economic sector, both in terms of economic performance and in growth in the number of companies joining the cluster. Growth took place at an average annual turnover rate of 19% according to Govt & Int D (2012). This was apparently a much higher rate than any other sector in the regional or national economy. This high rate of growth signalled a socio-economic transition of industry towards a sustainable-orientation. Govt & Int H (2012) who represented the regional industry association agreed that eco-world group of companies were performing exceptionally well comparatively – which he suggested was due to a strengthening of the sustainability-orientation of the RIS. Academic R (2012) suggested that Styria was seen as a kind of 'pilot region' for Austria in terms of endogenous regional development:

> That's something that's very specific for Austria and there has been also one specific concept already in the 1980's… that kind of preceded the sustainability debate, that of endogenous regional development.

This endogenous regional development promoted inward-looking economic activity. It also promoted entrepreneurship and a focus on finding local solutions to regional problems. For example the entrepreneurial solutions developed by the founder of Firm V (2012), that reconsidered the abundant resource of wood in the region as a fuel source:

> and so his vision was to change gas and oil boilers to wood boilers and then he asked himself – what have we to do that people change their boilers and he thought that we need the boilers they have the same comfort and they are also easy to handle so that's why he developed boilers they are full automatic to burn wood.

The local scale level - Local level refers to the grassroots and community level in the City of Graz and surrounding towns which was seen as extremely important in the sustainability-oriented development of the RIS. As evidence of the importance of the local scale, there are two sides to it: *first* local social interactions and connections between the RIS elements take place at the local level; *second* RIS actors are connected to local sustainability challenges. The examples of the wood boilers and the glass recycling technologies mentioned above were developed due to local social interactions as responses to local sustainability challenges.

In discussions with respondents, and in observations of firms clustering in specific geographic locations, the notion of socio-spatial contextualization in the RIS was apparent. Small towns like Gleisdorf, Murek and Weitz were home to specialized focus areas for sustainable technologies including: solar thermal and PV technologies, geo-thermal heating systems, bio-mass heating systems, waste recycling systems and others (Govt & Int E 2012). While there certainly existed market opportunities in Austria more generally, it was the regional focus on sustainability that kick-started many of these clean technology firms. There were strong local networks at the grassroots level that assisted in developing these technologies in partnership with universities and with government support (Govt & Int J 2012). Collectively they formed part of the RIS, and supported alternative or clean technologies which often began by entrepreneurs responding to the wider environmental consciousness movement of the 80's.

Another important dimension to the 'local level' was the learning, implementation and use of innovations for sustainability (Govt & Int C 2012). For example, the solar home technology movement and the recycling system of Styria both began as localized community engagements in society, later including government. In the case of recycling the local initiatives were strongly reinforced from the top-down, but the 'social' innovation and learning took place at the community level (Govt & Int I 2012). Intermediaries played an important role in the knowledge dissemination and learning about sustainability at the local level. This is confirmed by Govt & Int I (2012) who said – 'We work regionally and very locally'.

The city of Graz was also seen as a local spatial 'melting pot' of innovative activities. Graz was seen by Govt & Int E (2012) as a spatial location that brought together all the RIS elements. The close geographic proximity to four universities in Graz also played an important role in bringing together RIS elements. According to several respondents (Govt & Int E, J; Academic L 2012), Graz was the heart of the regional drive for sustainability, also being labelled the Greenest city in Austria.

Another pattern, which was discovered through observation and in discussion about the case with respondents, was the establishment of local 'niche' markets for sustainable technologies. Many of the technologies developed within grassroots communities (i.e. local scale), like the solar-home systems, the wood-boiler systems and the bio-diesel systems, also developed niche markets within those communities themselves. For example the bio-diesel was produced and sold to local farmers to use for their farm machinery – 'at that time it was strictly a local market because the first bio-diesel plant is still 40km from the city of Graz' (Firm X 2012). A similar story was true for all of the technologies and entrepreneurial ventures mentioned above: over time their markets expanded and they grew into successful medium sized enterprises. Good support mechanisms for supporting sustainability-oriented innovations are now in place in the Styrian RIS according to Firm Y (2012).

Building SCIs for sustainability also took place at the local level, where intermediaries played a big role through learning and education (Govt & Int C 2012). However, it was apparent that the high concentration of universities and available knowledge about sustainability in Graz was a key social driver of SCIs for sustainability. The city of Graz was a concentrated socio-spatial node that strongly influenced regional SCIs for sustainability. Cities and towns no doubt aided in the development and spread of SCIs for sustainability due to close social proximities. According to Govt & Int D (2012), there was a new social movement and consciousness for sustainability amongst the youth in the City of Graz:

> Certainly over the last few years, there was kind of progress, sustainable progress… people changed their mind, they are in the process of changing their minds if they think about success, if they think about ecological things. So I think we are moving to a more sustainable society. We do know... it's a long way to go and I think, though, there was this kind of progress happening over the last few years. Younger people, young people are involved in a revolution, like in the '60s, it is similar to that revolution. Not as big, but there is this kind of revolution going on.

Sub-section conclusion – spatial factors were evidently important in the formation and shaping of SCIs. National, regional and local 'identities' were the hallmark of socio-spatial characteristics and formed a deep and formal SCI in the RIS. These identities did not change much through time. It was also noticed that experimentation for sustainability mostly took place within communities at the local level.

6.12.2 Socio-cognitive institutions at different structural levels (micro, meso and macro)

The last section dealt with scalar and spatial perspectives of SCIs in the RIS. Here evidence of different qualities of SCIs on different structural levels is discussed. Understanding SCIs and how they are constituted both generally in society and in the RIS is similar to understanding a complex system. They are complex systems because both their boundaries and the factors constituting them are difficult to determine – they are not shaped by any single factor. Innumerable linkages can be made to SCIs and what may shape them, and how they may be constituted. However, despite the known limitations in understanding all possible influences of SCIs in the Styrian case, certain probable generalizations can be referenced, discussed and described qualitatively. Specifically for this section, when discussing 'structures' , the reference is to socio-cognitive institutional structures, which are narrower by definition than general institutional structures, or socio-technical structures in society. SCIs shape and are shaped by wider institutional structures in society, and arguably also spatial factors as described above. However for now, these spatial factors are omitted from this section. In a similar way that ISs shape production systems, SCIs may shape wider institutional structures and eventually socio-technical structures.

SCI structures exist both within and outside of ISs structures. SCIs within RIS structures, for example, may be more formalized, because they are supported by university research and knowledge development. Whereas external SCIs, developed within a community of practice, like the solar home interest groups, were at first informal because they were external to the RIS. At a later stage they became formalized because they were supported by elements in the RIS. Eventually the SCI surrounding the solar home system or technology, became formal enough to compete with other SCIs at the meso level. It is at the meso level that stable and dominant institutional structures are formed, yet they may be competing with other SCI structures at this level. At the macro level, there exist deeper or more rigid SCI structures within which meso level SCI structures are embedded. There may be several competing SCI structures at the meso level. At this point it should also be mentioned that SCI structures do

not need to be formed around any specific technology as is strongly advocated within the ST literature in the description of socio-technical structurations. SCIs may often precede any particular innovations and lead to social movements in society in general, which eventually has an effect on the innovations being developed within ISs. SCI structures for sustainability external to the RIS in the Styrian case were abundant. They included all the social movements to ban nuclear energy, hydro energy and the general grassroots movements supporting alternative forms of energy development. Recycling, was another social movement that later led to technologies and systems for waste recycling being developed (Govt & Int B, C 2012; Firm X, V 2012).

Macro-level SCI structures - In the context of the investigation, widespread socio-cognitive institutional structures reflected generalized societal positions. Policies and national research agendas are examples of more formal macro-level SCIs existing at national levels of government. Whereas trends, fads or sentiments are more informal, SCI structures can exist on a national scale. They are not spatially secluded, as are many local SCIs, and may exist across national scales, but neither are they rigid or formalized structures in the RIS (i.e. they are micro structures existing at the national scale). Another example, could be the view that farmers' markets are pleasant experiences for Austrians. The activity of attending a farmers market is a particularly localized experience, but it takes place across the national context of Austria (and Germany for that matter) (Academic N 2012).

SCI as Meso-level structures - In Austria and in Styria there were several meso-level SCIs that represented competing Austrian thinking, and that also changed somewhat over the last three to four decades (Govt & Int G 2012; Academic L 2012). At the macro-level, deeply rooted cultural SCIs have already been alluded to – the notion of an Austrian identity. This SCI can be summarized as proud, forward-thinking and conscious of maintaining a standard of excellence, within a socio-economic context of Europe and the world. The goalposts for measuring excellence (as a formal SCI) shifted from 'economic growth' to 'economic growth and sustainability' over the last four decades (Academic O & L 2012; Firm W 2012). This was reinforced by a strong legislative framework for environmental protection that was imposed on Austria as a whole (Firm T 2012). Certain events that took place beyond Austria, including the oil crisis, and most recently the financial crisis, affected the macro level SCIs. Similarly, societal events within Austria took place, such as protest against the nuclear station and the hydro power station, arising from SCIs favouring environmentalism,

> In this time it was really a crisis and people were looking for all sorts of new opportunities and the sustainability sector was one and they also went to other sectors of course but it created new ideas. Without this crisis the change would not have happened in this way.
>
> (Govt & Int 2012)

Politics also played a strong role in shaping SCIs, but also responded to wider societal SCIs at all levels. Often the informal SCIs became formalized through the RIS, also at meso- and macro- structural levels. For example, when a policy is put in place it alters the framework within which economic development takes place. Events supported by the 'green party' and the political momentum around environmentalism grew quite strongly. Coupled to socio-economic structural changes, society supported the idea of innovation in Austria in the '80's, because many people sought renewal in society (Govt & Int A 2012). With this macro-level SCI shift, also came the idea of focusing more on services in the economy rather than purely industry (Govt & Int H 2012).

> Industry is an important part of being in many ways the foundation or contributor of course, it turns out things plan and especially in the 90s and of course more recently, to overcome the image of destroying nature, being conservative in the approach, the whole society in a way was of course changing towards a more service-oriented society, service-oriented industry also involving ecological aspects so to say, from that perspective came a lot of changes that in my point of view innovation came much more positively accepted in society.
>
> (Academic K 2012)

All these macro-level changes in the SCI in Austria, were quite iterative: they were linked to and influenced by market forces and vice versa. However, as mentioned before, the media played a big role in shaping perceptions and SCIs in Austria (Academic O 2012). The macro-level 'structure' is different from the meso-'structures' in that it represents one dominant structure. On the meso-level, there exist multiple structures that may also be strong, but are not necessarily dominant across the board.[35] For example the SCIs of two competing groups in the Nuclear power referendum represented two meso-level structures. Once the one group won, and legislation was changed to ban nuclear power in Austria, for example, this immediately became a macro-level framework and structure.

[35] This is different from the ST literature which suggests that the 'dominant' or incumbent paradigm exists at the meso level. For example, although several socio-technical systems exist, one of them would be the 'prevailing system'. Here, SCIs structures may be different in that they compete as ideals, or knowledge bases etc. at the meso level.

The meso-level structures in society pertain to SCI structures that exist between the micro-level structures and the macro-level. In a general societal context, these are social structures that are stable, yet may also be in a state of flux, depending on the nature of the structure and its function in society. Various forms of institutions that serve part of society, but are not necessarily accepted by the entire society, could be regarded as meso-level. Political parties are a good example. There may be several meso-level structures competing for dominance.

Eco-world represents a formal institution that arose from micro-level SCIs for promoting a sustainability-orientation in the economy and now operates at meso-level. Govt & Int C (2012) suggest that the Eco-world meso-structure is an important component of organizational agency in the RIS playing an important role in actively shifting it towards a sustainability-orientation – 'Yes, and the exchange between business and university and community, this is something Eco-world Styria did [for sustainability] in the region' (Govt & Int C 2012). So the mandate of Eco-world was to formalize the existing social structures on the micro level towards sustainability on a regional level and further instil learning towards this on the meso and macro levels. Here again, the role of an intermediary is shown to be vital in developing SCIs. For additional examples see endnotes.

At the micro-level, several other intermediaries, including various alternative social movements, voluntary organizations, new discoveries, inventions, innovations and technologies that were supported in society, helped build these SCIs and assisted in formalizing them. See endnote.[o] Academic Q (2012) described such social movements as as social innovations: 'that's the driving force, I mean social innovation is what actually brings about sustainability'.

Entrepreneurs were often seen as individuals with alternative socio-cognitive paradigms that quickly began to surround themselves with like-minded individuals and resources. Various pilot projects were a direct result of alternative innovations that stemmed from micro-level socio-cognitive structures. The social SCI came first, and then the technologies and innovations followed according to Firm W (2012) –

> From the bottom, we have to do something and then there came the ideas of technology and you can do it also today. When we develop new products, most of the products are coming from the idea to save raw material for example.

Entrepreneurial ventures, and new technological experiments became demonstrable examples of change in society. They were socio-technical demonstrations in society serving as catalysts

for change. They helped to widen, deepen and formalize SCIs in the RIS and society (Academic P & Q 2012; Firm U 2012). The green entrepreneurs were described by Govt & Int B (2012) with admiring humour as 'freaks' who gave the region a head-start.

Dynamics between structural levels - Another interesting perspective is the dynamics between structures. For example when legislation was implemented to ban nuclear, new SCIs suddenly developed on the micro level 'searching' for alternatives. These SCIs were associated with seeking economic opportunities, but also took place in a macro-level legal framework that would support this (Academic O 2012). For examples see endnote.[p]

Sub-section conclusion - Socio-cognitive structures may exist at different spatial levels. However, their relative depth and rigidity in structure is formed by their relation to longer-term trends in society. The micro-level is where looser arrangements are developed as novel SCIs, often preceding inventions or innovations, or becoming the reason for small business ventures. New cognitive communities at the micro level eventually become more formalized and become part of the RIS at the meso level.

6.12.3 SCI and proximities at different structural and scale levels

Proximities, are a vitally important element in this dissertation, because they provide a conceptual lens with which to bridge both scalar perspectives and socio-structural perspectives like SCIs at different levels. As discussed in the literature review, proximities can take several forms, including spatial, cognitive, organizational, social and institutional. In Styria proximities had an integral role in shaping the RIS, but also in shaping SCIs for sustainability both formally and informally. Using the 'lens' of different proximities to *analyse* the data and findings enables one to gain a better understanding of how SCIs may be shaped both spatially and structurally. In the findings, there is a clear link between spatial proximities and the development of SCIs structures. However, this need not always be the case. SCIs as a part of the RIS or external to it can be influenced by spatially distant events or connections as well. Through analysis of the data and responses in the case, several examples are discussed pertaining to each form of proximity and how this may affect the shaping of SCIs. Reference will be made to the role of spatial proximities, where relevant. This allows for some comparison and link between spatial scales and structural levels.

Spatial proximities were not as important at all the socio-structural levels as initially believed by the researcher for the shaping of SCIs. *Social proximities* often went hand in hand with

spatial proximities especially in the formation and influence of informal SCIs. *Cognitive proximities* influenced SCIs more formally and were extremely important in the transfer of knowledge, and in co-operation between organizations in the RIS. *Institutional proximities*, were important in the formational influence of SCIs at different structural levels, more informally, at the micro-level and more formally at macro- and meso-levels.

The formation of SCIs, however, did depend upon the structural level and the spatial scale where the shaping took place or did not take place. At the *micro-structural level* for example, close spatial proximities at the *micro-scale* played a major role in the shaping of informal SCIs towards sustainability. At the *regional level*, different forms of proximity, for example organizational proximity, began to play a bigger role in the shaping of SCIs, especially in the RIS. At the *national level* spatial proximities played almost no role in shaping *macro-level SCIs*.

On the micro-level and scale, individuals drove specific socio-cognitive frameworks, which eventually became informal SCIs in their local communities as the basis of extended networks. Academic Q (2012) called these entrepreneurs 'bottom-up pioneers' who influenced the community around them. They influenced socio-cognitive institutions as social movements or they built networks of support for specific technology innovations. In many cases, these social movements, becoming communities of practice and eventually businesses, were often driven by strong visionary leaders. The growth of firm V (Wood boilers), firm X (Bio-diesel) and firm Y (Solar heating) all began with visionary leadership of individuals at the local level forming micro-level SCIs (Firm V, X & Y 2012). The networks that were built by these individuals were usually in close social and spatial proximity in their communities and small towns. According to Academic Q (2012) – 'it was like a network which changed the mind-sets of people'. Tight-knit communities believed in these visionaries and what they stood for – which in many cases was to drive solutions for sustainability challenges. This began to informally influence the community's perceptions and personal socio-cognitive frameworks, eventually developing informal SCIs. This occurred in close spatial and social proximities in towns and communities around the city of Graz.

The example of the start of the solar-home movement in small towns and communities is a primary example of the importance of spatial proximity for building alternative SCIs as micro-level structures (Govt & Int A & B 2012; Firm Y 2012).

Non-spatial proximities and their orientation to sustainability may have gradually influenced the existing SCI directions in the RIS, through new research directions chosen by universities, or the direction of search by CEO's of existing firms to support a sustainability-orientation. The systemic change of SCIs more formally within the RIS, however, took place in close social, organizational, cognitive and institutional proximity. To effect this change, spatial proximity played a role in the meeting places of the city of Graz, but it was less important than the other forms of proximity (Govt & Int H 2012; Firm U 2012). Other examples where spatial proximity may have affected wider level SCIs for sustainability were in the showcase environments that were very local initiatives.

The various pilot projects already mentioned, and showcases for sustainable technology were primary examples of spatially based influences in SCIs, including: the smart city precinct in Graz that came with electric vehicles and smart tramway showcases, the solar panel installation at the monastery, the various technological showcases of solar projects in communities, as well as recycling projects and a few others. These strongly influenced cognitive changes in individuals and groups that came into contact with or knew about these showcases through spatial and cognitive proximity to them and their creators (Academic K 2012). This notion was strongly supported by Academic P (2012) who suggested the power of these showcases for changing SCIs through learning by doing and 'seeing is believing'. The local level was regarded by Govt & Int H (2012) as extremely important in shaping SCIs: – SCIs are shaped by the location and the general culture of the population in that geographic space. So, e.g., the relative 'openness' of Styrians is also a feature of their attitudes and affiliations to particular SCIs. Accordingly to him, SCIs are also historical, with Graz and Styria being the 'centre' of the scientific community of the Hapsburg empire.

In Styria, examples of the cognitive framework of a single politician supporting sustainability at the regional level and how this influenced government administration to formalize the support of sustainability initiatives was given (Govt & Int B, C 2012). The cluster policy is a primary example of where both spatial proximity and other forms of proximity are equally influential.

> We talked a little bit earlier about the cluster concept, and of course a successful cluster is always limited to a territory in my view. And we have a very good size of the territory in Styria to do things [economically] but also to keep the communication up, between the stakeholders, and it's also especially Graz, is a small city, it's quite a good place to start innovation and to make them well known also.
>
> (Academic K 2012)

Similarly Eco-world as a cluster with a stronger sustainability-oriented SCI at the meso-structural level and regional scalar level was formed through time. Interactions that took place at the meso-level, through the various forms of proximity assisted in building SCIs for sustainability. The outcome of which was a sustainability-oriented cluster that was supported by the RIS, and in turn influenced not only other clusters to become more sustainability-oriented but assisted in building greater cognitive proximities towards sustainability-oriented research, and innovations. Closer cognitive proximities for sustainability were also reinforced and further formalized through research programs at universities, research institutes and competence centres. Financing of green and sustainability initiatives further reinforced and brought together elements and actors in the RIS through closer institutional proximities.

The orientation of RIS was influenced by the closeness or distance of institutional proximities. However, institutions were shaped and driven by the RIS as well. SCIs for sustainability, for example, on the macro structural level, were influenced by education programmes or national research agendas. These were macro institutions that resulted in altering SCIs at different structural and scale levels. Various social uprisings, for example the protest against the Nuclear power plant, were an example of macro-scale and macro-level SCIs for sustainability. The shift in thinking across the country led to rapid change of legislation, steering the RIS in a new direction for energy provision.

> It was the turning point in policy and in general thinking in Austria because ... afterwards there was a clear commitment, also from policy, to go towards renewable. This started in 1978 (after Nuclear)
>
> (Govt & Int A 2012)

For example, where firms were in closer institutional and cognitive proximity to research programmes supporting sustainability at the competence centres or universities this built more formalized and rigid SCIs for sustainability. At first, organizational proximity took place through building tighter networks of like-minded organizations, supporting a sustainability direction. This happened through initiatives like Eco-profit and Eco & Co that eventually led to a stronger and close form of organizational proximity in the form of Eco world (Govt & Int A 2012; Academic M 2012). Social proximities, were an interesting form of proximity because they were present at all levels of structure and although informal also served to influence formal structures like the RIS. As already mentioned the various social movements on the micro level are a primary example of this. However, the general tight homogenous social fabric and closeness of Austrians in general proved to be extremely

important in the sharing of ideas and spreading of SCIs across all levels and scales (Govt & Int B, C, I 2012).

Sub-section conclusion – It is clear from the findings that both spatial proximities and other forms of proximity play a role in the shaping of SCIs. However, the SCIs that were sustainability-oriented were more often shaped in closer spatial proximity that not. At higher aggregate levels different forms of proximity were prevalent and became important. Like cognitive proximity in the knowledge transfer between elements in the RIS (i.e. firms and universities) but also between various organizations as organizational proximity. Institutional proximities, were also shaped spatially, however, were not necessarily fixed to any specific spatial node. SCIs on the other hand, when they were in the process of developing around new innovations often were spatially specific.

6.12.4 Formation of SCIs in Styria through localized learning

Localized learning as the term suggests, is about learning in a local context. The various proximities as described above, no doubt, have an effect on localized learning. What was missing from the above concepts however, is an emphasis on how individuals, groups and organizations alter their collective cognitive frameworks through learning. As explained in the literature, localized learning is a special form of social learning that takes place in the proximity of other elements in the RIS. Learning for sustainability at various levels was regarded as the biggest driver of SCI formation at the local and regional level for the Styrian RIS. A summary discussion of the findings from respondents follows below. It starts with an excerpt about how AAE-Intec began as a localized learning initiative.

> I was quite young at that time, my first political activity was against this nuclear power plant. I think a lot of these people were influenced by this movement and then we were simply thinking what we can start in favour of something instead of just being against the nuclear power plant. And it's how we started our movement, and our first activities were – we developed a template system for solar systems. So it's basically that we established something in '82 a self-building movement in Austria for the solar thermal movement, this was our starting point. And this is, assembling systems on the market we had already collectors on the market which were low quality, high price and we thought we can do it cheaper and better. Which was finally the case, because with this system, we never sold this system, we organized training courses, evening lectures, we showed them how to build it, how to install it and with this we created something like 400 000 square meters of collectors. And based on this the companies saw there is a big market, there must be a big market if the self-building movement can do 400 000 square meters.
>
> (Govt & Int 2012)

This was a typical example of how social learning took place at a community level, in several small town locations across Styria. There was time spent on learning the new systems,

improving the systems and eventually developing a business out of them. Often localized learning for sustainability began, with the identification of local problems for sustainability. Individuals and community members, were often interested in how they could solve these problems – and as a result not only did joint learning take place, but new SCIs for sustainability emerged. Out of these initiatives, in many cases entrepreneurial ventures were begun. They were often not supported in the very beginning, but later gained traction as the wider RIS community took notice of the potential of many of these sustainability-oriented technologies (Govt & Int B & E 2012).

Localized learning did not always originate from the community, however. In other cases, localized learning was something that happened between local (regional) partnerships in the RIS. It existed and took place between businesses, universities and government in the RIS on a regular basis (Govt & Int C 2012). In fact, the strong proximities and ties within the Styrian RIS signalled continuous localized learning in the region. Another signal that the RIS system was shifting more and more towards a sustainability-orientation was the increase in research and learning programmes for sustainability.

> I think also government, in this case especially city of Graz, has a role to play in [localized learning for sustainability] eventually, for organizing for communicating for example this project and you can see, from other examples that people in Graz, are willing to identify with successful projects, with technology shifts, which will make them more acceptable and can contribute to sustainability.
>
> (Academic K 2012)

Academic K (2012) sees government and universities as having a responsibility to foster localized learning for sustainability, but also wider general societal learning for sustainability. The significance of localized learning is that it places the emphasis on local issues that are often to do with sustainability and require solutions in society. There were several social movements in Austria that reinforced localized learning for sustainability (Academic L 2012). Another classic example of localized learning is the implementation of recycling in the region as a process of localized learning for sustainability (Academic O 2012).

> And after the consumption, you must have the ability, the same ability to go to a centre, like a supermarket and it must be possible to separate all this different kinds of waste – electrical waste, plastic, metal, bio organic, minerals.
>
> (Govt & Int I 2012)

Academic P (2012) suggested that localized learning is important to change SCIs, especially towards sustainability. It is about breaking down old mind-sets and cognitive frameworks and developing new ones. Tangible projects that promote sustainability in society are good examples of ways in which to foster localized learning and transform SCIs. Localized learning may be enhanced or stimulated by practical doing, or projects on the ground. When asked, 'Is localized learning a necessary strategy in society, for fostering change?' Academic P (2012) responded, 'Ja it is, of course people like to learn, they are afraid of theories, people like to see something, like to touch something, to give some demos to go there and experience'. Practical projects and learning by doing were regarded as powerful drivers of change in SCIs at the regional level. The various responses by firms were especially supportive of the idea of that localized learning. They suggested that the solutions developed at the local level, were scaled up through support from RIS actors which led to strong alternatives to unsustainable systems in society.

> this is the nucleus where solar thermal in our region came from and in Austria we have the company Green One Tech which is, I think it is Europe's biggest solar thermal collector manufacturer, we have Solid, we have Eko-tech, we have AEE Intech, and I see the main position of our region in solar thermal. For sure this was supported by studies at the technical university; you had 2 guys coming from there studying this more deeply …
>
> (Firm Y 2012)

6.12.5 Lock-ins and macro, meso, micro formal and informal structures

Despite the multiple examples of localized learning to foster SCIs that support innovations for sustainability, transitions to more sustainable systems in the region of Styria still have a long way to go. At the time of the interviews clean-tech and the eco-world cluster was the fastest growth sector in the economy, but it did not have the largest share. This meant that many companies and industries remained unchanged, and continued to contribute to unsustainability. So, while dramatic socio-economic changes in a sustainability direction were present in Styria, this only had a marginal impact on changing the socio-technical systems in the region.

Lock-in, as described in the literature review, is a phenomenon where various institutional structures become rigid and co-dependent. Such lock-ins are described in the sustainability transitions literature as socio-technical, and in the path dependency literature as techno-economic paradigms (see Part I for details). The discussion about sustainability transitions in context of the findings will take place in Part IV. Here the findings are relevant to that

discussion but limited to a more sociological and institutional view of lock-in at different structural levels. Such lock-ins may also apply to social, cultural, legal, political and administrative structures that prevent SCIs from enabling change in the RIS.

Govt & Int G (2012), was of the opinion that, in some cases, sustainability-oriented innovations come on the scene too early, and society rejects them. He suggests, for innovations to be adopted in society, there needs to be a fine balance between innovation push, and the gap within society to accept the innovation. Govt & Int J (2012) suggested that society is heavily dependent on technologies, and patterns of behaviour are locked-in. So, for society to change these patterns, new technologies need to be implemented. But, for this to happen, the legal frameworks need to change first, especially at the entrepreneurial level. At the more macro-level, the financial system and expected future earnings of corporates and shareholders are strong lock-in effects. This prohibits socio-economic transitions. According to Academic M (2012) regulations didn't really affect the emergence of the clean-tech sector in the Styrian RIS that much: 'It was more an entrepreneurial or innovation push, which was heavily influenced by regional dynamics, and in a way the spatial proximity of this knowledge base to entrepreneurs and industry as well'.

Academic O (2012) suggests that public pressure and opinions – informal SCIs – placed pressures on government to change legislation. This pressure created windows of opportunity (in the language of STs) for entrepreneurs and for shifts in the more rigid meso-level socio-economic structures.

Academic Q (2012) points out that there are different levels and differing structures at these levels. His view was that, for sustainability to occur, there needs to be a complete restructuring, not only partial. Firm T (2012) agreed. It also strongly agreed with the following statement by the researcher, which describes another form of socio-economic lock-in that prevents SCIs from enabling transitions:

> I mean it's survival actually, of the firm….it's a structure that exists, it has a reason to live, it does, and it has it's reason to continue earning profits even if it might be a little bit unsustainable, even if it's product might be unsustainable, correct? Respondent: absolutely.

Large firms and incumbent socio-economic structures like the fossil fuel energy complex were given as examples as barriers to entry for smaller firms such as Firm V (2012). Firm V's technology was an alternative sustainable energy source for heating, using wood. He suggested that they struggled to enter the market at a larger volume due to barriers being

placed by larger energy firms, which were able to lobby the government to retain legislation that favoured them. This prevented the alternative technology from gaining more than 3% market share (Firm X 2012).

Formal structures, at the macro-level like legislation often prevent SCIs supporting alternative innovations or technologies (Academic O 2012). Markets are another strong force that prevent alternative SCIs from influencing the RIS, on wider scales or more rapidly (Academic K 2012). Politics also played an important role in enabling or locking-in certain SCI perspectives at the macro level. In some cases however, politics was overruled by wider SCIs that were in favour of more sustainable options, like the nuclear issue. The government and several politicians were in favour of commissioning the station which was already built – yet society vetoed this decision with a popular vote (Govt & Int A 2012). However, sometimes society is locked-in to consumerism and to informal patterns of thinking of SCIs that are deeply ingrained in society.

> The question is do I need, do I need really water scheme, do I need walking devices, do I need every 5 years a computer, do I need … it all costs money and they are able to produce products for a longer term, but they don't do. You can produce cars, it will last 15 years, but they don't do. And that's the question, so we are in an ending world and we want to have endless growth, and that's impossible. So we have to reduce ourselves but we cannot reduce ourselves coz then economy will fail and we don't earn so much money and you cannot exchange goods without to pay taxes.
>
> (Govt & Int J 2012)

At the meso-level, several formal rigidities and lock-ins were discussed. Intermediary institutions and the more formal mechanisms of the RIS, were often locked-into financial and legislative arrangements. In most cases, in Styria at least, these arrangements were positive for promoting collaboration and sustainable development in the region. However, when it came to influencing the direction of search, and research at competence centres – this was not always seen as positive. The reason being that the type of research being demanded by industry, which was funding a lot of the research, was for incremental innovation. Incremental innovations often lead to slight improvements in existing socio-technical structures despite their unsustainability (Govt & Int G 2012). For example the car industry spent millions of Euro's on R&D so as to improve fuel efficiency only slightly.

However, as suggested, many of the formalized structures on the meso-level, were put in place to promote sustainability within the Styrian RIS. Eco & Co. and Eco-world cluster management organizations and policy are an example of formal meso-level structures that

strongly supported the meso-level SCI (Govt & Int B & I 2012). Formal funding structures and market incentives put in place at the meso and regional scale for sustainability strongly reinforced SCIs for sustainability. At the micro level, there were not many formalized structures that created lock-ins to prevent SCIs for sustainability from expanding. However, informally the micro-level had serious socio-cultural lock-ins'.

In many cases, informal lock-ins and social structures like culture and public perceptions which formed part of SCIs were often the most powerful barriers. According to Govt & Int J (2012) there is a 'psycho-social pressure on society' to behave in a certain way in society, to consume, to work, to perform all which contributes to some cycles of unsustainability. The perpetuation of similar economic patterns, are informal structures that in fact inhibit change, or SCIs supporting sustainability. Academic N (2012) suggested that SCIs leading to behavioural changes in society are very slow – and used the example of gender equality. Another more slow-moving SCI, on the macro scale, was that of innovation practices in industry. There was a long period were incremental innovation in industrial processes was strongly promoted. More recently, industry and the private sector is being pushed to produce more radical innovations not only to survive economically but also for achieving sustainability (Academic P 2012). Several of the respondents, suggested that informal SCIs like perceptions in society only change, once a crisis or some form of pressure is placed on them (Firm V 2012).

In Styria however, the informal SCIs, like attitudes, perceptions, values and norms were very often in favour of sustainability. Over the years, an environmental 'consciousness' changed to a sustainability 'consciousness'. Academic R (2012) suggested at the informal level, there is a *'consciousness shift for sustainability'* in the region. Similarly according to Govt & Int D (2012) there is a shift in SCIs in Styria:

> I think the people are more open-minded and they believe more in sustainable kind of living, like .., you know and it's not important to be the best, to run more than others, to be happy with your life and to do what you dream to do, but I think this is sort of progress and we are still in this mind shifting process.

Another respondent Academic Q (2012) reinforced the idea that society in Styria was further ahead in its informal SCIs for sustainability than the RIS was in hosting formal SCIs.

> I would say that the way it goes, on the one hand from society which is much further in front in terms of sustainability at least, than either the business or the political side. So societal pressure actually is at the moment driving the whole thing.
>
> (Academic Q 2012)

At the macro level, through the last four decades, there have been tremendous shifts in informal SCIs as societal thinking – this has shaped socio-economic structures and directions. At one point, in the 2000's society may have felt that its environmentally conscious thinking, or SCI for the environment was enough. It then shifted its focus back on economic growth. More recently this shift moved back to sustainability issues in the 2010s (Govt & Int 2012). When pressures, like melting glaciers, climate change and sustainability issues, begin to affect people more closely, then it begins to change their SCIs (Academic L 2012). Politics and media, are other powerful drivers of public sentiment and informal SCIs. The political concept of Ökosoziale markwirtschaft was an early notion of sustainable development that was specifically promoted in the Styrian region (Academic Q 2012).

There are many drivers of SCIs and changing public perceptions at the meso-level. Academic Q (2012) considered voluntary organizations and various associations to be powerful drivers of SCIs at the meso-level. One respondent pointed out that, at the meso-level, there exist many different informal SCIs, that are continuously changing and in opposition to each other. This also takes place within the RIS, and the different formal elements. This pattern is described below in the statement:

> I think you have to divide society – society is not the whole complex, society is divided into segments and you have the economic segment, you have the public segment and you have the private segment and there are different thinkings in it. There are barriers between the thinking the awareness.

Most often, the more dominant SCI in society is the one which has the most critical mass. It has an influence and bearing on other SCIs on the macro-level, and is able to influence SCIs on the micro level (Academic L 2012). At the micro level, informal SCIs are also a powerful driver of change. This has been evident throughout the descriptions of the findings. This may range from individual leadership that builds SCIs around itself, such as the numerous innovation champions that have been discussed. It may also include researchers at universities who provide inspiring research to influence the cognitive trajectories of external groups or students. However, micro-level SCIs are no match for wider SCIs and deeper structures that must shift if sustainability transitions are to occur.

6.13 Conclusion of case 1 – The Styrian RIS

The Austrian, and Styrian socio-economic landscape shifted dramatically over the last thirty years. It was riddled with sustainability challenges, eventually overcoming them in a dramatic showing of innovation for sustainability. The direction of innovation, was powerfully driven

by the SCIs of environmental movements in the 1980s. This movement, coupled to the industrial break-up of SOEs, sparked a shift and momentum in the regional innovation activities towards sustainability. Many of the innovations that were developed in this direction did so from the bottom up. However, with the break-up of old industrial clusters new industries emerged out of the old. It was primarily the strength of the knowledge system in the region that allowed for rapid adaptation, and with it innovation towards solving the challenges like pollution, energy challenges, transport, waste, waste-water etc. Although, many of the solutions, as innovation were developed at the grassroots levels, but quickly supported by institutions and organizations, like government and the financial intermediaries. Most interestingly the SCIs were found to be strong drivers of the shift in the regional innovation system towards a sustainability direction. These findings are discussed in greater detail, in Part IV.

While the Austrian case represented a historical socio-economic transition, with many related examples of socio-technical transitions, the South African case was quite different. It serves a different purpose, in investigating a contemporary transition of societal visions, but looks at the same questions, and coding categories of the theory. The primary reason for the use of two cases is to give a more holistic and dual view to the findings. As will be seen from the case of 'Transforming Technopark' below – a considerably different set of insights are generated about the potential of governance of STs from an IS perspective.

7 CHAPTER 7 - Case 2 – 'Transforming Technopark' in the Western Cape Regional Innovation System

The findings of this case investigation were centered on a contemporary study of micro and meso-level socio-cognitive institutions embedded within the regional innovation system of the Western Cape. The case study had two focuses: one at the regional scale, covering the Western Cape and the Cape Town City region, and the other a local scale study of Technopark and Stellenbosch, a town in the Western Cape, South Africa. The study of Styria in Austria was a retrospective historical analysis. This case is a study of a work in progress.

The Western Cape case is different from the Austrian case in several respects: *first*, where the historical perspective was important in the Austrian case, this study focuses on contemporary dynamics in the formation of a vision and strategy in 'Transforming Technopark'; secondly, its main focus is on the micro scale and social level instead of more structural and aggregate level; *thirdly* it is an ethnographic study, using a transdisciplinary approach to the case. This means that a new vision and strategy was co-developed with the researcher and various local innovation system (LIS) actors, based in the town of Stellenbosch; *fourthly*, this project developed in the context of the development and conceptualization of the regional innovation system of the Western Cape (W.C. RIS). *Finally*, the timelines, and the narrative of events and changes in SCIs are tracked and highlighted against various claims, and validated by real-world occurrences, such as the establishment of the Technopark 'special ratings area' and new board of directors, as well as the Stellenbosch Innovation District that was a spin-off of the intervention. The aim of the findings is to show how a TD research intervention led to changed SCIs as new visions and actions towards sustainability.

The findings provide valuable insights towards answering the research questions. While the South African and Austrian cases differ in focus and in timelines of investigation, certain generalizations that can be made that the projects share. In both cases, however, there are novel perspectives which are revealed in Part IV.

Stellenbosch is the second oldest town in South Africa, founded in 1679 by Simon van der Stel, the Dutch East India Company Governor of the Cape. It is a small university town, with a long history of promoting learning (Stellenbosch University, 2015). In the 1980s, on the initiative of the then vice-rector (research), Prof. Christo Viljoen, Stellenbosch University

established a Technopark on the periphery of the town. This was at the height of Apartheid, when economic sanctions were taking their toll, and the South African authorities of the day were trying desperately to innovate to become self-reliant. Technopark was to form an intricate part of the local, regional and national economy. Technopark is one of the best examples of an attempt to replicate in South Africa the global concept of science parks, such as Shinshu in Taiwan and Silicon Valley in the USA. In fact Shinshu in Taiwan was a direct inspiration for Technopark Stellenbosch.

The history of Technopark (TP) is interesting. It is the story of a failed science park, but a successful hybrid innovation and technology park. (It remains listed on the UNIDO website as a Science Park)[36]. During the 1990s the park management relinquished tight control over the park for a number of reasons, including slow development and uptake in the park, due to tough economic times in the rapidly changing South African political climate of the period. A decision was made to change the business model, and allow for ad-hoc commercial interests to enter the park. This changed the nature of the intended development from a fully-fledged science park to a hybrid technology and business hub.

A brief historical background to the case study is interesting and informative for the analysis, because, despite the weak governance or management of the park, it remains one of the most innovative spatial agglomerations in South Africa. While the exact reasons for this attractiveness are unknown, it is assumed to be because of the close proximity of the University of Stellenbosch, among other things.

Technopark should also be understood in the context of Stellenbosch town. Several attempts in recent years have been made to drive a programme of sustainability for the town. These include the 'Sustainable Stellenbosch' initiative that began through the Sustainability Institute[37] in 2009. Several other projects in the town have since been initiated through efforts by the University and local municipality. One example is the 'Infrastructure Innovation Committee' (IIC) a joint university- municipality initiative to address the infrastructure issues in the town. This was kick-started by the Rector-Mayor forum, an attempt to address governance challenges of the town through a memorandum of agreement for collaboration. Another initiative by the University is the establishment of a business incubator, managed

[36] http://www.unido.org/en/how-we-work/convening-partnerships-and-networks/networks-centres-forums-and-platforms/technology-parks/mapping/africa-sub-sahara-region/south-africa.html
[37] http://www.sustainabilityinstitute.net/

independently, but kick-started by the university's technology transfer office, InnovUS.[38] The incubator is known as the LaunchLab[39].

Furthermore, Stellenbosch as a town is considered one of the most innovative micro regions in South Africa, forming an important part of the regional innovation system of the Western Cape (W.C. RIS). It boasts a considerable number of company head-offices, a rich conglomeration of venture capital, and multiple innovation-award winning micro- and medium-sized companies. Many of them are situated in Technopark. Stellenbosch University is rated as one of the top research institutions in Africa, and ranks well internationally[40].

7.1 The Regional Innovation System of the Western Cape

The national Department of Science and Technology (DST) has for some time tried to establish a governance programme[41] to improve regional innovation systems around the country. One of the programmes was situated in the Western Cape Province of South Africa. This followed the recommendation by the Cooperation Framework for Innovation Systems between Finland and South Africa (COFISA) to establish regional innovation systems, and move away from focusing purely on a national system (COFISA, 2006). COFISA completed a study on the regional triple-helix networks, and provided an overview of the strengths and weaknesses of this system (COFISA, 2009). In fact, a comprehensive study was conducted on Stellenbosch town by COFISA. The recommendations of this report, were to establish and formalize an office to co-ordinate innovation activities in the town (Lamprecht, 2007). This report, was not only used as secondary data, but provided the departure point for the current study. It was clear that Technopark and Stellenbosch, as a local innovation system, was embedded in the wider Western Cape Regional Innovation System (W.C. RIS), so the researcher found it necessary to include regional perspectives in the study as the context for understanding the local level case of Stellenbosch and Technopark, which is the primary focus. The work was formally supported by the Western Cape Department of Economic Development (DEDAT), as well as the Technology Innovation Agency (TIA), to provide insights into the progress of establishing a governance forum for the W.C. RIS. Permission was granted for this regional work, conducted by the author, to be included in this study. The primary data was collected through the author's interviews and multiple engagements with

[38] http://www.innovus.co.za/
[39] http://www.launchlab.co.za/
[40] http://www.topuniversities.com/universities/stellenbosch-university/postgrad
[41] http://www.gov.za/department-science-and-technology-forges-ahead-building-innovation-systems-provinces

regional stakeholders of the IS. That part of the research was useful for the W.C. RIS programme, and simultaneously allowed the author to capture primary data for the current study. The immediate findings of the regional work were compiled in a report for DEDAT, which can be found online[42]. This report was subsequently used to inform development of the regional innovation system of the Western Cape. Stemming from these national/regional initiatives, and through synergies in the research work that was being conducted by the author, the Department of Science and Technology (DST) took an interest in establishing a further feasibility study into Technopark and Stellenbosch as an Innovation District (SID).

7.2 Stellenbosch Innovation District

SID is a programme first supported by the DST, with a project commencement date of October 2012. The programme set out to assess the feasibility of establishing Stellenbosch as an Innovation District in its own right, including the feasibility of revitalizing Technopark as an innovation hub/ science park (with a focus on sustainability and technology). The programme aimed further to establish an online platform and network of innovation practitioners (innovation forum) for Stellenbosch, as well as to develop a full scale business plan for the innovation district. SID is an on-going project, driven by a steering committee with members from big business leadership, the University of Stellenbosch, the Municipality of Stellenbosch and civil society.

7.2.1 Brief background to the South African policy landscape

The micro-scale and structure, and the regional scale and meso-structures described above need to be placed in the context of the national scale and macro-structures. An overview of the South African policy landscape in the context of climate change is provided here. This information should be regarded as supplementary to the case, assisting in contextualizing it. Several South African policies provided a strongly supportive macro-structural environment for transitions to SD at the national scale and structural level. These policies include, but are not limited to:

a) **The national strategy for sustainable development,** set up to support enhancing systems for integrated planning and implementation, sustaining South Africa's eco-systems and using natural resources efficiently, working towards a green economy, building sustainable communities and responding to climate-change more effectively.

[42] http://www.saine.co.za/wordpress/wp-content/uploads/2012/02/Regional-Innovation-System-of-the-Western-Cape.pdf

b) **The Green Economy:** is a governmental strategy which aims to reduce resource use, as well as the carbon intensity of the economy, to provide equitable access to resources and a decent quality of life for all citizens, and to integrate sustainability concerns effectively into all policies, planning and decision-making at national, provincial and local levels (NSSD, 2010:10).

c) **The New Growth Path:** is the fruit of work the National Economic Development Department was tasked to undertake in 2009, with the aim of placing South Africa on a more equitable and sustainable growth path that would address some of the key economic trade-offs required to in the process.

d) **The National System of Innovation (NSI) in South Africa:** South Africa was one of the first countries globally to consider the concept of a 'national system of innovation'. The initial framework was developed in terms of the Science & Technology White Paper (1996). However, several subsequent documents and policy briefs inform the NSI, including the National Research and Technology Foresight (2000) and the National Research and Development Strategy (2002). As part of the same process, in 2008, the Ten Year Innovation Plan (TYIP) for South Africa was published. It is designed to 'transition' the entire economy from being a minerals and energy complex to being knowledge-based. The plan departs from a view of where the country should be in 2018 to look for ways of achieving higher growth from an increased knowledge base (TYIP, 2008). A particularly significant goal of the TYIP is for South Africa to be 'a world leader in climate science and response to climate change'. This shows a commitment by the national government to achieving a low carbon society. Such a commitment is part of the backbone of the NSI strategy. Although this is a positive development, the NSI of South Africa has not yet achieved anything like its potential. An underperforming education system, social instabilities, and skills shortages are the primary issues of concern. It has simply not been possible to enhance the national R&D output at the rate envisaged.

e) **The National Development Plan:** This plan was developed as a thirty year guiding vision for the whole of South Africa, and includes a strong rationale for transitioning the economy towards sustainability through innovation (NDP 2013).

7.2.2 Summary of the case timeline and 'Trandisciplinary Interventions' by the researcher

The Austrian case was conducted over a period of one year from 2011 to 2012. However, the South African case and associated events that took place after the initial intervention Transforming Technopark spanned several years from 2010–2014. These initiatives catalysed into a wider project, Stellenbosch Innovation District or SID (2013 on-going). In addition to the Municipal response to innovation in the project called Stellenbosch Innovation Capital, SID is regarded by the researcher as an external validation of the case. While these programmes are briefly described, they did not form part of the case study, and do not fall within its scope. A recent further validation of the success of the primary intervention, the Transforming Technopark (TTP) project, was the establishment of a special ratings area for Technopark. This was achieved through a public vote, in which the proposal received overwhelming majority approval. The proposal included a business plan based on the TTP strategies and included the same vision statement.

While most of the interviews and data gathering were conducted before the researcher left to do the benchmark Study in Styria in 2012, substantial follow-up interviews and events that the researcher was involved in took place after this period as well. For example, the researcher was invited to be a part of the Technopark Owners Association (TPOA) Management Committee; and was appointed the programme manager of the SID project until 2014. The researcher considered these activities as directly related to the TTP case, and they allowed him to reflect on the developments. The research to an extent continued his direct involvement as ethnographic experience. The extended period of involvement also allowed for a retrospective view of the TTP case. The continued involvement of the researcher allowed for continuous connections to be made in his mind between the TTP case and the SID programme. This was viewed as a natural progression, and resulted in an extension of the TD intervention of the Transforming Technopark project.

After two years of programme management by the researcher, a formal steering committee, headed by the regional senior partner of an international firm of accountants, was appointed to take over the leadership of the SID project. It consisted of representatives from local government, the university of Stellenbosch, big business and innovation experts and was aimed at bringing together triple-helix stakeholders, and becoming a platform of engagement for the LIS of Stellenbosch.

The researcher's perspectives and ethnographic experience of not only the conceptual SCI transitions that took place during this time, but also the informal and formal institutions that were formed to support this are detailed and discussed in the findings. The researcher's perspectives and experiences were captured in summary documents that the researcher prepared during the TTP process as public documents for stakeholders to view and approve. However, there was a richer data set: the researcher's personal notebooks and e-mails were shared with various stakeholders for comment and validation during the period of research.

Table 13. Timelines and dates of the various interventions and events

Timeline of events and researcher involvement in case study		
Research process	Dates	Supporting information in Appendix 'E5'
Pre-study (Technopark)	June 2010 – November 2010	N/A
1) **Public Visioning Workshop (Technopark)**	4th June 2010	Appendix E5 Summary document.
2) **Intervention – 'Transforming Technopark'**	January 2011 – June 2012	Appendix E6 Examples of various minutes of meetings during the research study period.
3) **Stakeholder Engagement, Meetings and Interviews (Technopark Owners Assocation and Firms, Stellenbosch Municipality, Stellenbosch University, Local Government, Firms)**	Continuous (2010 – 2011)	Appendix E5 A summary document that summarizes the stakeholder inputs and agreed upon vision for 'Transforming Technopark'. All extracts from interview transcripts, and workshop recordings.
4) ***SISN Vision Feedback Workshops**	16th February & March 2011	
5) ***TPOA Visioning Workshop**	June 2011	
6) **Regional Innovation System of the Western Cape**	January 2011 – October 2011	Report of 'Regional Innovation System Strategy Document'
***Participation in workshops**		
***Interviews with regional stakeholders**		Extracts from various interviews
***Report including secondary data analysis**		
Styrian (Benchmark) Case Study	August 2011 – August 2012	
Invitation to join TPOA as trustee	September 2012	
Launch of SID programme & Events	26th October 2012	Evidence of events held.
1st SID – Stellenbosch Innovation Conference	2nd July 2013	Public event
Held in conjunction with the 19th Annual		

ISDRC Conference		
1st SID Public Visioning Workshop 1st + Event on Transitioning Stellenbosch Town into a sustainable and Smart City 'Smart Cities for Africa'	6th November 2013	Video evidence
Municipal Event: Stellenbosch Innovation Conference 'From innovation to winning nation'	1st & 2nd October 2013	Evidence of flyer, programme and event summaries.
SID Zero Waste Workshop	18th March 2014	
Formation of SID Steering Committee	August 2014	Summary documents and reports of SID
2nd SID - Stellenbosch Innovation Conference	30 & 31st October 2014	Visit www.innovationdistricts.org
Formal Approval Technopark SRA TPOA committee transformed into TechStel SRA Not for profit Company (NPC)	1st June 2015	E-mail evidence and on website www.technopark.org.za

7.2.3 The narrative of the South African Case and content analysis of data

The South African case differs from the Austrian case in the way that the findings are presented for each investigative theme. (1) Under each investigative theme, the narrative of the case study is presented, from the perspective of the researcher. (2) A first-hand account of the case findings is then revealed from an ethnographic perspective. The experience and account of the researcher is made explicit because he was deeply embedded within the Stellenbosch case as a TD researcher. (3) To provide additional evidence and to validate the researcher's claims, a content analysis of the various interviews is provided. Not only are the interviewees' responses *analyse*d, using the coding categories, but also the responses of the researcher, who was embedded in the case as one of the actors.

7.3 Narrative of the transdisciplinary research process–'Transforming Technopark'

When an informal pre-study was conducted, prior to the official research in 2010, the researcher recognized that Technopark would make a good transdisciplinary (TD) case study. In trying to formulate the (wicked) research problem, the researcher had informal discussions with several business people in the park. Adopting an ethnographic approach, the researcher spent time in the park, walking around, speaking to people, asking them about their understanding of TP, and gauging their views and opinions about what the park 'was' for them. Taking several photographs, the researcher used a different lens (literally) to view the

physical terrain and infrastructure in TP, revealing the more apparent issues of a lack of maintenance and general neglect of the public spaces. The park, which was designed as a 'science park', also had issues with traffic congestion, too little parking, no public walkways, dilapidated public spaces, poorly maintained dams, broken irrigation systems and other issues. Initially, in speaking to the business community and public in the park, nobody was able to say who the leadership of the park was or if there was any management body. This already signalled to the researcher that deeper and more complex social, institutional or organizational issues required attention.

The researcher, in his own mind, and later in conjunction with the TPOA and several other stakeholders, identified three interrelated issues. *First* was the quite obvious lack of maintenance, neglect and physical unsustainability of the park, which the TPOA was very well aware of. *Second* issue raised by the researcher about the vision of the park and the associated mandate to be a 'special zone one' and the expected formal management component of the park as a science park or innovation hub, did not seem to be part of the TPOA agenda at any point in the initial discussions. The *third* issue or point of concern, raised with the TPOA, was that, although they were legally zoned as a 'science and technology' park (a special zone-one), there were no formal institutional connections with either the university or municipality.

From the researcher's perspective, Technopark was far closer to a technology or science park than publicly perceived at the start of the research. The researcher saw this as an opportunity to assist the management and owners of the park, firms, the municipality, the university, and various other stakeholders to begin a process of transforming the park back to its original intended identity as a science park, or similar concept. The immediate issue that the researcher experienced in engaging with the tenants in TP, and also the TPOA and other stakeholders, was a general lack of knowledge about science and technology parks and their purpose. The park was in fact legally zoned as a 'special zone one' or 'science and technology park' – yet there was little or no knowledge of what this meant among most of the stakeholders (Govt & Int E 2011). There was also little understanding and comprehension about broader issues relating to a science or technology park and its purpose in society.

The researcher saw this as an opportunity for driving a consultative transdisciplinary project through co-developing a renewed vision for the park. The primary stakeholders were the TPOA, who were the legal owners of all the private property in the park. The majority of

property owners were also business owners in the park and had an interest in improving not only the infrastructural environment but also the business environment. The park was a 'hybrid park' and a public-private-partnership, because the biggest single land owner in fact remained the municipality of Stellenbosch, which was also supposed to service the 'open areas' and public spaces of the park (Govt & Int F 2011). Due to the municipality's neglect of this responsibility, and for other reasons, the building owners had the TPOA legally constituted as a trust or association in April 2009. The purpose of the association was to address the issues of maintenance in the park, and charge voluntary levies on the building owners to finance this. The private owners and firms in the park, and various stakeholders, including the municipality, were well aware of the issues (Govt & Int F, 2011).

When the researcher approached the TPOA in early 2010, although sceptical, the management agreed to work with him. It was also at this point that the researcher and the TPOA slowly began to co-develop and influence the socio-cognitive frameworks of a small group of actors in TP. The small groups of actors were in strong favour of a renewed vision for the park, and represented a sub-committee of the TPOA. It was called the 'Aesthetics and future of Technopark' sub-committee, and it met on a regular bi-weekly basis over a period of almost a year. The purpose of the sub-committee was to develop a relationship with the researcher and the university, and to better understand the purpose and value of the research and give feedback at the wider monthly TPOA meetings. However, many misconceptions, fears and social conflicts arose early on between TPOA members who held different views, and in some cases involving the researcher as well.

Part of the issue was that the researcher did not communicate in a 'language' which was understood by the TPOA who were all business people. This is an important point. The researcher was perceived as far too academic, and due to his intentions to conduct transdisciplinary research, the aims or goals of his work were seen as undefined or at best not clear enough. The researcher tried at times with some difficulty to guide a process towards a common vision for the future of the park, and to collectively set goals to achieve this over a five year period under the banner, 'Transforming Technopark'. Among the issues that arose was that the TPOA was accustomed to professional consultants who came with pre-defined solutions, rather than a researcher who spoke about a process of 'co-development.' The researcher's manner of identifying the problem, and insisting on finding solutions 'together' was not common practice. In fact, the idea of TD research was completely foreign to the

TPOA, and to several other stakeholders at the time who were used to paying somebody to think on their behalf. This was an interesting finding, and it already signalled the existence of different socio-cognitive paradigms between the academic researcher and the TPOA. Over the period of the project, the cognitive frameworks of both the researcher and TPOA changed considerably, signalling mutual learning and co-development of a novel SCI. It took a number of engagements before the purpose of the research and aims of the researcher were understood by the TPOA and other stakeholders (TPOA & Firm P 2011). At this point it was decided that a public visioning workshop should be held to involve a wider constituency in the 'Transforming Technopark' project (TTP). At this workshop several strengths of the local and regional innovation system were revealed.

7.3.1 The 'Transforming Technopark' visioning and strategy development process

The 'Transforming Technopark' project was regarded by the researcher as a TD process, of continuous engagement with the TPOA and wider stakeholders. Although the TPOA sub-committee gave inputs into the process, it was driven in partnership by the researcher. The first step was to organize the public 'visioning workshop' mentioned above, with a wider group of participants from both within and outside of Technopark. The next step was to continue engaging with smaller stakeholder groups, including the TPOA, but also not limit the process to any one particular stakeholder group. It was decided not to create a rigid process, to allow a natural progression of events, processes and inputs to unfold. As a researcher, it was the writer's responsibility to be embedded within the social structures of the TTP process to gain an emic (insider) perspective and prepare an ethnography. This was fully understood. The researcher made his role explicit to the stakeholders as a 'TD research consultant' who was researching and participating simultaneously. This in itself was a novel approach to individual TD research, and was not received without initial misconceptions. In time, trust developed as a TD group with the TPOA, and thereafter friendships. Various 'social' structures were co-developed due to the TTP process. These included the more formal sub-committee structure, but also the 'Sustainable Innovation Stellenbosch Network' (SISN) which was set up to provide a platform for engagement with a wider group of stakeholders for TTP.[q] The first two SISN engagements worked quite well, but had to be stopped due to lack of resources and capacity by the researcher who took responsibility for organizing the events. However, the intention was to continue with the forums at a later date. This eventually happened in the form of the SID programme including the whole town of Stellenbosch. The final intervention that formed part of the TTP process as a parallel process

with the TPOA was the formalization of the vision, and the development of a short, medium and long-term strategy for the park (See Appendix E5). Each of these TD intervention processes will be briefly described below. Each intervention had a different effect on the SCIs of stakeholders, but also on the final outcome of a strategy for transforming technopark into a sustainability-oriented innovation hub.

7.3.2 Public visioning workshop 4th June 2010

The public visioning workshop on the 4th June 2010 was the first major intervention of the research. It involved around 80 people who were stakeholders from within and outside of Technopark including: the TPOA, firms in the park and their employees, members of the local government, academics from Stellenbosch University, and civil society. The workshop took place on the 4th June 2010 at a location within TP, with an independent facilitator from the local CSIR[43]. The researcher was able to participate in the workshop, which was recorded[44], and the data was used anonymously.

First, information was given to the attendees in the form of several expert talks. Speakers included a researcher who shared the findings of her PhD research on the 'Innovation Hub' in Pretoria. Thefindings suggested that close spatial proximity of firms in a similar industry were not always positive, but often helped to stimulate idea generation and further innovations. The programme also included a perspective on the green economy by a member of Green Cape, a regional government intermediary. Green Cape's strategy about developing a clean-tech cluster in the region was discussed, and how Technopark and Stellenbosch formed an important socio-economic resource that could contribute to that plan. The researcher also gave a brief introduction to his plans in working with the TPOA to establish a vision for the park. He provided some context about TP, and the various sustainability challenges. A focus on sustainability was also strongly encouraged by the researcher, explicitly informing the intention to transform the park towards a sustainability-orientation. The researcher provided examples of similar innovation parks globally, to be used as examples and discussion points for the workshop component. The workshop was the first localized learning process for sustainability initiated by the researcher.

The participants were divided into several large groups, and asked to discuss the future vision for Technopark by 2015, and thereafter what the possible blockages to achieving this vision

[43] CSIR – Council for Scientific and Industrial Research
[44] The intention to use the data anonymously for the research was made known to the audience.

might be. They were then asked to prepare three key words that could potentially form part of Technopark's mission statement. The participants responded engaged creatively in the exercises and provided insightful perspectives which are summarized in Appendix E5 (Summary of TTP visioning workshop). Insightful responses about the current situation were provided, some of which included frustrations about the dysfunctional LIS:

> the frustration is that there is knowledge out there but it is not being implemented and it's not available for the teaching of students. So the dream, the vision is that there should be co-operation available as soon as possible between those that have the knowledge and those that want to, or are in a position to make change. For us to do this we have to change mind-sets. (Summary thought from Group 1 – Visioning Workshop)

Other responses included a clear vision for a more sustainable TP, and made a few distinctions between social and infrastructural requirements for transitioning the park towards a sustainability-orientation. One of the groups responded by suggesting the need for changes in technology, but emphasized that these changes should be led by human-centered approaches. They suggested that technology should be used to reduce our resource use, but this shifted to suggesting that to achieve this the most important resources were in fact people with the right skills or capabilities:

> Communication between people and businesses [is important], but also you have kind of a forum or have an internet based chat facility for human interaction. And then we looked at technology, that will follow automatically the technology that you will require in terms of waste, in terms of energy, all those things we hope would actually follow the fact that you're making it attractive for your primary resource, the human side and then the interaction with the environment, in other words to a certain extent we're looking at how with the future Technopark design looks like incorporating the environment rather than being something that takes over the environment as such. Make it attractive for people to live here and to work here because it does interact with the environment. So we've been, we started off at the technology end and we said no, we've got to focus on the human side and the technology will almost be dragged along as a result of that (Visioning workshop 2010).

There was also a strong emphasis on the need for 'transforming' the current infrastructure and open spaces to enhance social interaction in the park.

> Green routes and bicycle roads that connect Technopark with the rest of Stellenbosch. Better public transport, that's also a very good way for people to connect with each other and ja, meet new people and share ideas, that kind of thing.[r]

Again the need for creating a space for social engagement at the local level was re-iterated by another group. However, this group suggested the need to develop inclusive collaboration and new informal institutions between disconnected communities and spaces in the town of Stellenbosch.

> In 2015 we'd like to see a kind of a market place here, a place where there's a hub, lots of activities going on here, where people exchange ideas and share ideas within the Technopark community but also with the communities outside the Technopark, like for example Khayamandi, like for example the university.[s] Visioning Workshop 2010).

And,

> The one thing that was missing was setting targets, what kind of targets are we going to set in terms of water reduction, can we have some kind of public forum which monitors that target? Are we going to be able to monitor our resources? [t] And then one interesting comment from an outsider was, and he's the guy who supplied the wine and we wanted to say thank you very much to him, Mr Paul over here – was - how is Technopark as a community going to be conscious, like the wine farmers at the moment, they have a drive to be conscious of the people living on the wine farms, conscious of their ecosystems, conscious of the surroundings, conscious of the environment around them. How is Technopark as a whole going to be conscious of its own surroundings and its own infrastructure for example, okay that was about it (Technopark Visioning 2010).

The groups were also asked what the primary blockages were to achieving this vision in 2015. The responses varied from strong social aspects to various financial and resources constraints. It was suggested that there was a general lack of leadership to provide the momentum for change. One respondent suggested the dire need for changing mind-sets of people, so as to get 'buy-in' to the new vision. Various resources including financial and human capital to achieve the vision by 2015 were regarded as the primary constraints (Visioning Workshop 2010).

7.4 The Sustainable Innovation Stellenbosch Network (SISN)

The SISN was an informal structure set up by the researcher as a continuation of the first public visioning workshop. Its purpose was to continue the public discussions, and to start a parallel process to the TPOA sub-committee who were included in the SISN. On the one hand, it was intended as a social activation or movement for supporting the proposed vision in the wider TP community, but also included external stakeholders from the university and municipality. On the other hand, it served the purposes of a validation process for the TD research in developing a common vision and strategy for TTP.

There were however, only two SISN events or workshops, because the process required additional resources and capacity which the researcher did not have at the time. Another reason was that there was a view that a website could replace the aims of the SISN through an online forum and discussion board. The first SISN event and workshop was used to ratify and further develop both the vision and the strategy for TTP. This was done through providing the participants with a summarized version of the vision and a proposed strategy that was

developed by the researcher in consultation with the TPOA sub-committee.[45] Various inputs were provided by the TPOA sub-committee as well as a broader range of stakeholders. These inputs were collated and summarized by the researcher, and can be found in Appendix E5 (SISN Summaries).

7.5 The Technopark Owners Association visioning workshop

This workshop took place almost a year after the TTP process had begun in 2010, and after a lot of discussions, meetings and engagement with the researcher and the TPOA had taken place. During this time, the researcher had gained the trust of the TPOA sub-committee, and slowly also gained the trust of the wider committee. Initial fears were that the researcher represented a hidden agenda of the university, and had been sent to gather information on how to regain control of Technopark as a 'science park' under the University's management (TPOA & Firm J 2011).

One of the minor aims of the workshop was to formally dispel these fears which had remained in the minds of some of the committee members. It also provided the platform to consolidate all the inputs gathered through the TTP process. Specifically it was to formalize the vision for the TPOA and ratify the proposed strategy going forward. It was a formal procedure that involved the use of an external facilitator, to guide the workshop with the TPOA. The researcher was given an opportunity to provide a summary of all the inputs and processes that had gone into the vision and draft strategy, which included the processes described above. The programme also included feedback from individuals who represented the municipality and the university's senior management. The researcher had held informal discussions and consultations with many of the key stakeholders in the Municipality and the University. The unofficial viewpoints of the University of Stellenbosch and the administration were also provided to the TPOA in this meeting.

The TPOA committee were given an opportunity to do their own visioning workshop based on all the information they had received. The format was similar to the public workshop. However, it was far more intimate and there were only ten participants, including the

[45] The first meeting took place on the 16th February 2011 in Technopark with over 40 attendees, the second meeting took place on the 16th March 2011 outside of Technopark at a local wine-farm with about 25 attendees.

facilitator and the researcher's supervisor.[46] The formal vision that was decided upon, and ratified by the committee was:

'To enable and create a Sustainable, Vibrant and Active Innovative Community'

It was decided that the strategy document prepared by the researcher would be used as a longer-term guiding document for TPOA activities into the future. A version of this strategy document prepared for the TPOA can be found in Appendix E5. The strategy was divided into three components:

i) **Immediate action plan** - To identify and list tasks of immediate importance for Technopark, and to establish stronger relations with the University of Stellenbosch and the Municipality of Stellenbosch.
ii) **Medium-Term action plan** - Expansion of Technopark and Zoning Considerations.
iii) **Long-Term action plan** - Integration and alignment with regional Development Plans and Visions. Including incorporation into wider vision for Stellenbosch as an innovation district.

7.6 Individual meetings, interviews and stakeholder consultations

During the TTP process which began in 2010, the researcher found it necessary to gain additional perspectives and insights from key individuals. The intention was for this to be an additional data source, and form of validation for the researcher's ethnographic perspectives. Some of these individuals represented the University of Stellenbosch and the Municipality of Stellenbosch in their perspectives of the TTP process. These included senior members of both organizations including: the Vice-Rector: (Research), senior staff members of InnovUS (the local university technology transfer office), as well as viewpoints from various academic staff. Academic staff were involved in and invited to the SISN forums and public visioning workshop and were kept updated on the TTP process via e-mail and through personal interactions with the researcher. The researcher also engaged regularly with the administrative staff of the Municipality of Stellenbosch, and formal meetings and interviews were conducted with: the municipal manager; the director of economic development and planning; the official in charge of municipal property services; and the official in charge of

[46] The researcher's supervisor had provided valuable guidance in the entire research process, and assisted in validating the claims of the researcher.

local economic development. Several local councillors were also included in the discussions, and their viewpoints were considered, although they were not included in the formal interview sample.

More formal interviews were conducted with select individuals that formally represented the positions of the administration of the municipality, the university management and the TPOA members who were both business and building owners in Technopark. To gain a wider perspective, on the process of TTP from a RIS perspective it was necessary to include stakeholders at the regional level. Although TTP was a local project that took place on the micro- scale, the structures and institutional networks that were built extended to the meso- and macro- levels.

The prior involvement of the researcher in the study of the W.C. RIS not only extended the institutional support for the TTP project, but it also unlocked governmental funding and support (for SID). The vision of TTP, slowly began to formalize as it became institutionally embedded within wider RIS and even NIS elements. Formal interviews were used in the data analysis to provide validation for the answers to the research questions, which included the researcher's own findings as a TD ethnography.

7.7 Findings Theme 1 – 'Transforming Technopark' in the W.C. RIS

The findings and viewpoints of the researcher are aimed at providing evidence for answering the research sub-questions:

Do strong and functional RISs have a greater capacity to enable socio-economic transitions to sustainability? and

Do weak RISs have less capacity to influence socio-economic transitions to sustainability?

Figure 5.1 shows a comparative description of the percentage of coded segments for Theme I. It is a snapshot of coded data of the interviews, found in Appendix E2 - SA Theme I codes

7.8 Context of the Regional Innovation System of the Western Cape

Through the TTP project the researcher began to develop not only local, but also regional networks. It became evident, that for the 'Transforming Technopark' (TTP) project to enhance its chances of real success, the regional innovation system of the Western Cape

(W.C. RIS) should be *firstly* better understood and investigated by the researcher; and *secondly* connected with the local and spatially-based innovation system of Technopark and Stellenbosch. This recommendation was also made by one of the senior managers from InnovUS, who was part of the W.C. RIS steering committee. He suggested connecting with certain stakeholders who were trying to develop a regional innovation forum (W.C. RIF). This W.C. RIF interim steering committee was tasked to bring all regional innovation role players together on a regular basis as the 'regional innovation forum'. This recommendation was an outcome of the engagement with the National Department of Science and Technology (DST) during the COFISA programme. The DST's mandate was to aid in funding and setting up these regional innovation forums in most provinces of South Africa (COFISA 2010).

After some initial engagement with the DST, the Technology Innovation Agency (TIA) and the regional Department of Economic Development and Tourism (DEDAT) who were spearheading the initiative, the researcher became involved. There was a mutual agreement between the researcher and the RIF Steercom and DEDAT that the researcher try simultaneously to fulfil both their research requirements and his own. Research at the more aggregate regional level was required for the Steercom to develop a document that could guide the regional role players into action. This process was valuable to the researcher, who then immediately became embedded in a wider regional context. This was an important connection for the TTP case study to gain perspective. Later in the study this engagement proved to be invaluable in providing the financial support from the Department of Science and Technology to conduct further work in mobilizing an 'innovation district' which was sustainability-oriented. The researcher's experience of being directly involved in the RIS networks, was seen as a continuation of the ethnography from the micro level to the meso level, or regional scale. It provided a wider academic vantage point from which to gain insights into the TTP case study in Stellenbosch. The researcher conducted four additional months of stakeholder engagements at the regional level (May to August 2011).

Several formal meetings were held, and several formal interviews were conducted for the research that was required for the interim RIF Steercom. A 'findings' report was also drafted by the researcher for this RIS interim steering committee. This was agreed upon with the researcher upfront, as it would assist them in better grasping the direction the RIS could take and what needed to be done to improve its functioning. The report required an intensive research period of collating reports and secondary data, various notes, and minutes of

meetings that the interim steercom had worked on over the two previous years. The researcher also found it necessary to conduct additional formal interviews with key stakeholders in the province. These interviews were included in the content analysis (CA) as primary data. The report that was developed, although authored by the researcher, was a collection and assimilation of existing and past information on the RIS. The experience of 'doing it' could be used by the researcher as an additional resource; and secondary data source to complement the interviews. The insights gained from the extended boundary of the case study allowed for invaluable insights, and also steered the research into a new direction to include a wider analytical lens of the RIS. The various findings from the case can now be discussed below from the local and regional context.

A form of validation of the researcher's perspective, is the findings from the CA of the interviews. The CA allowed for a degree of objectivity and systematic analysis of the interview responses, but also served as a framework to organize the researcher's own notes, and thought processes of the ethnography. It also provided a degree of distance and objectivity from the ethnography, and the researcher was able to reflect on his own experience during the analysis phase of the interview and other contents from the case. Combining the interview findings with the researcher's own experience below, provides an integrated perspective on the results of the South African case. The coded segments of the interviews, were used as both triggers to remind the researcher of specific feedback in the interviews, and where relevant incorporated directly into the findings below.

7.8.1 The strengths of the local and regional innovation systems

Despite noticing the specific 'problems' with Technopark which were required for a critical research study, Technopark and the town of Stellenbosch had considerable innovation strengths and capabilities. Stellenbosch as a town and TP as an agglomeration formed a vital spatial innovation node within the RIS of the Western Cape (RIS W.C.) and the South African IS. Although the symptoms of both strengths and weaknesses in the innovation system could be recognized in the Stellenbosch case, the RIS perspective provided further evidence. From a regional perspective, Cape Town, can be regarded as a productive and functional economic city-region. It has four Universities, two of which are ranked among the top universities in the world. The Cape Town city-region (including Stellenbosch) could possibly be compared to the whole region of Styria, but also a considerably different socio-economic context.

Although the knowledge capabilities of W.C. RIS were probably the biggest asset in the region, there were also several other strengths and capabilities including: a reasonably well-organized support of economic sectors (in the form of special purpose vehicles or SPV's); a coordination between the four Universities in the city-region by the Cape Higher Education Consortium (CHEC) of Stellenbosch University, University of Cape Town, Cape Peninsula University of Technology and University of the Western Cape; reasonable administrative and financial autonomy; although fragmented there was also keen government institutional support; and from the private sector a strong push to develop an entrepreneurial culture (W.C. RIS Strategy 2011; W.C. RIS Actor R 2011). The SPVs were the equivalent of the Austrian cluster management bodies, although heavily subsidized by the regional government. At the time of the research there were sixteen SPV's or sector development agencies, each with industry appointed CEO's in the RIS. These were viewed by the researcher as sectoral innovation systems (SIS) and included various sectors such as: oil and gas, boat-building, metals and engineering (tooling and moulding), plastics, the financial sector, clothing industry, business process outsourcing and a new 'green economy' or clean-tech sector called Green Cape (W.C. RIS Strategy 2012). For the purposes of the research only the 'Green-Cape' cluster was of specific interest and relevance for the case study at the regional level. Interviews were conducted with Green Cape's senior management (W.C. RIS Actor T & U 2012). This intermediary body was the equivalent of 'Eco-world' in the Austrian case, but had been operating for only about one year at the time of the interviews. Green Cape were also involved in the TTP project and presented at the visioning workshop and the SISN forums as guest speakers. Another important organization providing leadership, and shaping SCIs at the regional level was Accelerate Cape Town (ACT) (W.C. RIS Actor W 2012). Their leadership also revealed the considerable strengths of the Western Cape region from a corporate and private sector perspective. The most noticeable inference from the interview, according to them, was the natural beauty and live-ability factors of the region. It had a hugely positive impact on the economy. The attractiveness of the Western Cape as a place to live and work, enhanced the capabilities and skills of the region considerably according to ACT's views.

In a similar vein, Stellenbosch had primary strengths of natural beauty, and the surroundings in the Winelands made it an extremely attractive place to live. The live-ability factor was regarded by several respondents as really important in attracting skills and capabilities to the RIS (Govt & Int C1 2011). It was one of the primary reasons why members of TPOA & Firm

J & P (2011) located their firms in Technopark. Stellenbosch University is one of the leading universities in Africa, and the town also hosts, in close spatial proximity, several globally relevant research centres, including the Council for Scientific and Industrial Research (CSIR), and Nietvoorbij and Elsenburg, both agricultural research institutions. In an interview with the Vice-Rector (Research) evidence was provided of the strengths of the University in innovations in health-care, bio-diversity research and climate science, as well as sustainable technologies Academic A (2011) Interestingly, the respondent suggested the university's strengths lay in the strong inclination to do transdisciplinary research work. An important project for this kind of research was branded the HOPE[47] project, this was an initiative to further research for society, and further enhance the developmental capacity of the University (Academic A 2011). Other innovative strengths in Stellenbosch are that it hosts several headquarters of multi-national companies, and Technopark has over two hundred small and medium sized companies. Many of these businesses are innovative in nature, but do not necessarily fit the profile of a Technology park or a science park (Academic A 2011). However, those firms that are resident in the park, including the headquarters of a bank, several engineering firms, technology firms, a satellite technology firm, and several innovative IT companies, are mostly very successful. Many of the more successful firms, are direct spin-outs from the University including a satellite manufacturer (Sunsat, now SpaceTec), or indirect spin-outs such as well-known IT firms including MixIT and FireID. Funding and financial resources are both an asset and issue in Stellenbosch, which is home to a large percentage of all of South Africa's venture finance. However, the accessibility of this finance is restricted to large investments, and at the start of the research was not designed to cater for smaller start-ups.[48]

Both Stellenbosch and Technopark contribute considerable strengths and capabilities in the wider RIS. Although the town of Stellenbosch, hosting Technopark and Stellenbosch University forms part of the wider Cape Town city-region, it is its own municipality. Geographically, the proximity to the city center is about 50 km, and about 30 km to the Cape Town International airport. It can be regarded as an integral node within the wider W.C. RIS. But in many ways it also forms its own spatial innovation node with a unique cultural identity, many of the actors preferring to be ideologically separate from Cape Town. As

[47] Visit www.sun.ac.za for more information on the hope project.
[48] However, more recently, promising signs of increased accessibility for venture capital for start-ups, and stage-one funding support was noticed in Stellenbosch as Cape Town.

experienced by the researcher, there was a very strong *neighbourhood effect*, as discussed in the literature. This was good for building tighter networks within Stellenbosch, but not good for connecting to the RIS level actors. One reason for this is that Stellenbosch, together with the University and Technopark, and other businesses in the town can be considered as constituting its own spatially-based local innovation system (LIS). The town is also traditionally Afrikaans, which provides a natural socio-cultural neighbourhood effect.

There are both strengths and weaknesses in the Stellenbosch LIS, and in the context of the RIS it has considerable potential to enhance capacities towards a sustainability-orientation. This was evident from discussions with various experts in the case, but also from simple observation, and being embedded in the case as a researcher. Stellenbosch has strong innovation and knowledge infrastructures, and some strengths in interaction at least on the informal level between the University and industry in the town, whereas university-industry collaboration is more formalized at the national level, with larger corporates, and less so with SMME's (Firm O 2012; Academic A & B 2011). The presence of several sustainability-oriented companies in Stellenbosch and Technopark also shows a strength towards clustering of green industries. For example, one international firm in particular was assisting in identifying the required skills and capabilities for wind energy in the region (Firm K 2011). Stellenbosch had a high concentration of skilled workers with strong capabilities in the (green) engineering, legal, financial, agriculture, health and IT sectors. The University of Stellenbosch, hosted both the academic programmes and the research activities of the Sustainability Institute (SI) and the Centre for Renewable and Sustainable Energy Studies (CRSES).

Mini-conclusion – Both the regional innovation system of the Western Cape, and the local level innovation system (LIS) of Stellenbosch had considerable innovation system strengths. This ranged from natural beauty and the physical attractiveness of its geography to excellent tertiary knowledge systems and research institutes. There was a strong financial sector, and reasonably well-organized support for economic sectors. The seeds of socio-economic transitions to sustainability had only just begun to sprout in the regional innovation system, and were novel socio-cognitive concepts in the LIS. The W.C. RIS could be described best as having great potential, but not harnessing it effectively – which highlights the systemic challenges that are turned to below.

7.8.2 The weaknesses of the Western Cape RIS

The findings of this sub-section are associated with research sub-question 2b: *Do weak RISs have less capacity to influence socio-economic transitions to sustainability?*

Two COFISA reports formed the departure points for the PhD research. One report, entitled *'Triple-helix networks of the Western Cape'* dealt with the regional level and the other was a pre-feasibility study entitled *'Establishing Science Park activity in the Eastern and Western Cape Provinces'*. Both these reports and other COFISA work (e.g. *Enhancing innovation in SA – the COFISA experience 2010*) provided well-established research findings that could be built upon in the case studies. What was also evident and known from the outset was the dearth of any innovation policy specifically aimed at governance through a regional innovation systems perspective. RISs were a novel concept to the region. Hence the establishment and support from a national level for the creation of the RIF, as described above. The findings of cases, at the regional level and through the TTP TD project at the micro-scale, confirmed many of COFISA's findings. Due to the nature of more focused PhD research, the findings of the case study by the researcher have added considerable depth and insights to the COFISA findings. What was most prominently discovered by the researcher was the extent of disconnect between elements and mechanisms in the RIS. Stellenbosch was seen as an excellent micro 'site' embodying the complex issues that were reflected at the regional scale and meso-structural level.

The micro scale and structural level of the Stellenbosch case, however, were embedded in the wider regional structures. Within these structures, regional socio-economic and ideological differences between actors in the RIS were considerable. This had and still has) a severe crippling effect on the functionality of the RIS. For example, the notion of supporting the SPVs and sector development, coupled with the ideas of clustering industry, was hotly debated (W.C. RIS Strategy, 2011; W.C. Actor W, 2011). Interviews with certain respondents at the regional level revealed a perception that the regional government was ineffective in understanding the needs of business; but also that the sector approach had created siloes within industry, and hampered industry collaboration and interaction in the RIS:

> People like [*X*] and [*Y*] have added to that by creating 16 or so SPVs. So they created siloes, this one has got a CEO, that one has got a CEO, etc. Huge amounts of money that gets spread out thinly across the CEOs and they achieve very little.
>
> (W.C. RIS V & W, 2011)

It was for this reason that an alternative structure called the 'Economic Development Association' (EDA)[49] would take over the management of the SPVs, and their support and oversight would be removed from direct governmental management. The alternative would be support from the proposed EDA intermediary (W.C. RIS Actor V, 2011). The apparent rationale was to reduce the level of political influence in economic activities. As observed from the researcher's perspective, these political and institutional dimensions had a major effect on the RIS, and its ability to organize itself.

At the local level of Stellenbosch, and within the TTP process, the researcher was far closer to the issues of social, organizational and institutional conflict and disconnect. The embeddedness of the researcher in the TTP case, allowed for an insider's perspective. From that perspective, investigating the Stellenbosch case, was like using a magnifying glass on the RIS weaknesses at the regional level. The first weakness, quickly recognized by the researcher and discussed continuously with case participants, was the systemic weaknesses, and the poor level of connectedness of the RIS elements. For example, the strength of the LIS is an isolated strength, and there were serious concerns about the functionality of the RIS as a system. The Stellenbosch LIS, is like an island within the wider RIS. Many of the RIS and LIS elements functioned extremely well independently, but as a system it is weak (W.C. RIS, 2011). At the time of the study, however, there were promising signs of the various isolated strengths coming together. See endnote.[u]

The TTP project was an excellent case to illustrate the issues in the LIS and RIS. There were few if any informal connections between the University and the TPOA, and their relationship with the local Municipality was dysfunctional. The Technopark triple-helix relationships were extremely weak, and were symptomatic of the same issues on a wider level and scale in the RIS.

The discussion with Firm I (2011) was an excellent example of the general issue of disconnect. – The spokesman was chairman of a considerably influential ICT infrastructure company in South Africa with its head office in Technopark at the time. The discussion explained in detail the extent to which ICT infrastructure influenced the economic and innovation capabilities of a region and the nation. This company was involved in a

[49] The EDA, later became the 'Economic Development Partnership' (EDP) and was ratified by the regional government council in 2012, and was mandated to perform certain economic and innovation intermediary duties in the province. Please visit www.wcedp.co.za for up to date information.

consortium that had invested large amounts of capital in international ICT infrastructure cables from Africa and South Africa. They provided a service to internet service providers (ISPs), through laying 'Dark Fibre' cables and providing a far cheaper alternative to government infrastructure. The dark fibre required the ISPs to invest in lighting the cable, and bringing the technical capabilities and additional bandwidth to its customers. The point of the example is that Technopark and its businesses were bitterly complaining about their lack of access to faster internet speeds. Yet the 'disconnected' capability literally lay on their doorsteps. The fibre infrastructure to have the fastest internet speeds in the country was there, yet there were zero collaborative efforts by firms in TP to remedy this. The perspective of Firm I (2011), suggested the issue was a specific 'economic' problem of demand. However, from the perspective of the researcher it was a wider symptom of disconnect in the RIS. There was an absolute distance in organizational, social and institutional proximities, despite the very close spatial proximities between RIS actors. For example, in discussions with many of the stakeholders in Stellenbosch, and with firms in Technopark, it was revealed that most of them were not aware of the latent ICT capabilities. Yet, that type of ICT infrastructure could be regarded as an invaluable asset to firms and to the TPOA management for enhancing the attractiveness and capabilities of the park.

The TTP case allowed the researcher to further investigate the issues of disconnect in the RIS. The various workshops and visioning exercises gave the researcher a specific perspective; a slightly different perspective was provided by the formal one on one interviews, where respondents could be more open. In the TTP process, the various worldviews or SCIs of government, academia, the TPOA and firms differed considerably. The relationship between the local government and the TPOA was strained and dysfunctional because of a lack of understanding and appreciation for each other's situations (TPOA & Firm J & L, 2011). The lack of capacity in the municipality was, however, through various engagements with the TPOA better understood by both parties (Govt & Int H, 2011). The municipality had considerable resource constraints and pressures for service delivery, from previously disadvantaged communities in the town, as well as having to deal with huge expansion of their municipal boundaries to include a number of smaller towns and villages.

> Two years ago the Techno Park said that they're not getting the service from the municipality that they want. We neglected their parks… any sidewalks adjacent to a private erf we don't cut anymore. Because with the amalgamation of municipalities, the area just became so vast in 2000.
>
> (Govt & Int H, 2011)

They could not be seen to favour wealthier areas by providing additional services to TP – which was supposed to be done – as TP was a 'special zone one'. Some members of the TPOA regarded their lack of service in the park as incompetence, for example – 'but because from a certain delivery point of view our government's system is dysfunctional. The answer is probably, we are living in Africa' (TPOA & Firm L3 2011).

Social interaction and connections between organizations was a clear weakness in Technopark. The neglect of infrastructure and public space in fact had a major impact on the interactions between firms in the park. Many of the firms, for example were not aware of each other's existence, due to a lack of social space in the park. This was seen by the researcher and several respondents as a major weakness and infrastructural failure (Academic B 2011; Firm J 2011).

> No, I mean when you talk about collaboration there isn't any collaboration. We all basically arrive here, we sit down at our desks and we do work…Techno Park could benefit from having a nice opportunity where you can go for lunch, the coffee place, ja… that's the only really nice place that you can go to, you don't really have a place to go to… if you would create an opportunity where you eat lunch. If there is a demand, where they might actually also go afterwards and think about having a drink and easily connect to the businesses this would be a very good thing.
>
> (Firm J, 2011)

TPOA & Firm P (2011) responded in a similar way when asked the reason for the interaction failures, and the reasons for not knowing what other firms are doing in the park:

> Why? Because we have no interaction whatsoever. I don't know who is sitting in this building, how many people they are and what they are doing.

Coupled with the interaction failures within the park, there were also found to be wider institutional and capabilities failures between government, the private sector and the university.

From a regional perspective, it was suggested that the 'framework' conditions for innovation and economic development in support, particularly by government, were misaligned and misunderstood (W.C. RIS Actors S, V & W, 2011). The essence of these discussions at the regional level is captured here:

> We have been meeting with the Department saying - "Your role has to change as much as to set up an EDA outside of government", and we had a bit of a showdown, I think, this week with them, because we said; "You're playing, you're doing micro economic projects", and they have very little impact on the economy. Whereas if you played a transversal role within government in a better vertical collaboration, you would have far more impact on creating a better business and investment climate.
>
> (RIS Actor V 2011)

And

> But they don't infuse themselves and their mind-sets don't understand innovation because by doing it, it means they're ready to give away their kingdom in some way, because they are now part of something bigger. And I'm just saying this because that is the sticky truth.
>
> (W.C. RIS Actor S 2011)

It was also noticed from the case study that there were few interactions between the firms in Technopark and the university. In discussions with firms in Technopark about their view of the graduate student, there was a big gap between the theoretical knowledge and practical knowledge in the 'real world' as suggested by TPOA & Firm K 2011:

> Because there will be thinking or a line of thinking from the University saying, listen we are an academic institution. Our role stops at the end of the academic year of the final year student. Thereafter businesses and society must take over and use this person and we have got nothing further to do with it. From a business point of view we will most probably say, and I remember that from the law practice, we most probably say listen – the guy comes from the University, he actually knows nothing about practice so we must sit in and from day one we must teach him all over again, the practical side of it.

This was not only an issue at the local level in Stellenbosch, but also at the regional level. As discovered in discussion with Academic A (2011) the universities in South Africa are far more focused on helping to solve developmental challenges, than interactions with SMMEs. At the time of the research, this was changing, and discussions with Academic B, (2011) suggested that the University of Stellenbosch was making efforts to bring research and business closer together. This was to begin through their proposed incubator and entrepreneurship programmes. However, from the perspective of the researcher, there were deep fundamental SCIs structures that persisted in the university systems. They would take a long time to shift.

What was also promising at the time, and showed room for building new institutions between government and TP as well as the University, was the institutional structures that were created through the TTP process. The visioning exercise was a fundamentally important process to drive new SCIs in the wider society, and between stakeholders involved in Technopark. It also sparked collaboration between the municipality and the TPOA, when there previously wasn't any. Another important driver of the vision, was the discussion about industry specialization, not only for TP, but for the town as a whole.

Mini-conclusion – The weaknesses of the RIS at the regional level, severely hampered the effective functioning of it. These weaknesses were primarily as a result of disconnect between the elements in the RIS, and weak or non-existent institutions. However, it was clear

that W.C. RIS was in a phase of initial development. Coupled to this were several institutional projects and programmes to improve the institutional capabilities of the region, and the systemic functioning of it. Linked to this, was the emergence of a sustainability-orientation and awareness of the economy. Green Cape was the primary driver of this at the regional level. At the local level, the systemic disconnect was pervasive. It crippled the latent potentials and innovative capabilities the town of Stellenbosch has. However, efforts from the University and through the TTP project were mildly promising.

7.9 Theme II – Future visions as new SCIs of Technopark and regional stakeholders in the RIS

The findings of investigative theme II aim to reveal insights to answer the research sub-questions:2a. *How do SCIs within RISs have an influence on the direction and qualities of innovation outputs in the regional/local economy?* As well as 2b. *To what extent are socio-cognitive institutions a determining factor for sustainability-oriented innovation systems resulting in pathways for socio-economic transitions?*

The Austrian case extended back four decades, and evidence of socio-economic transitions to sustainability could be easily validated. In the TTP transdisciplinary research process the purpose was to investigate contemporary SCIs (rather than working retrospectively as in the Austrian case). This was done through the researcher's initially tracking a process of establishing of a joint vision for Technopark. Through a natural progression and extension of the case, the boundary of the case expanded to include the meso and macro level structures at the regional scale. The TTP process thus became contextualized through extending the structural boundary of the case – making the Stellenbosch case an embedded case study within the Western Cape RIS. The various primary codes and sub-codes of the findings are depicted in Appendix E3 (SA Case - Theme II). It is useful for grasping graphically which codes were most prevalent in the data, and thus focused on by respondents or the researcher in the TD case interviews.

The visioning processes have already been described above. This section will provide additional insights into this process, in context of the ethnography, interview feedback and involvement in the regional level part of the study.

Influences of SCIs in the TTP were understood and captured by the researcher, whilst he was embedded in the case on a micro scale. The TTP visioning process, however, also represented

a co-evolving micro SCI structure that eventually extended to the meso and macro levels. Through the TTP project, a sustainability-orientated SCI micro-structure began to develop in the context of the vision of Technopark becoming an innovation 'community'. The notion of innovation as a vision eventually extended to include the whole town of Stellenbosch – becoming the even wider SCI of the 'Stellenbosch Innovation District' (SID).

The extended SCI was achieved through social, organizational and institutional proximities and networks extending to meso- and macro-levels from the TTP project. Inclusion of regional organizations like Green Cape from the outset aided in this process. It also had an effect on the SCI micro-structural levels of actors in the TPOA. The researcher's involvement in the regional context was important for gaining a clearer view between spatial and structural levels. It also allowed the researcher to make significant connections between the micro-, meso- and macro-structural levels and between local and regional scales. Moreover it provided the researcher with additional perspectives into the ethnographic component of the case at both local and regional scale levels. Although necessary to clarify the approach to the inclusion of the different scales and levels here, this discussion is further revealed in the findings for theme III.

In the Austrian case, shifts in SCIs of actors through time lead to influences on the sustainability-orientation of the RIS and socio-economic transitions in the regional economy. In the contemporary Stellenbosch case, the aim was to get an insider's view of changing and shaping SCIs in developing a vision for sustainability and innovation. From the outset, the researcher was interested in the dynamics between spatial proximities and SCIs between actors involved at the local and regional scale levels. This focus became sharper with the extension of the understanding of proximities to include e.g. cognitive, organizational and institutional proximities in the content analysis. The understanding of closeness and distance of these forms of proximities as degrees of structure of SCIs at the levels of micro-, meso- and macro- were then also included in the analysis of the case.

As already described above, a formal vision was eventually established for Technopark during the TTP after one year. However, from the perspective of the researcher, the research did not end there. The researcher remained embedded within the case, despite the formal research process of initial interviews being completed. This allowed for an additional perspective on the case developments over time. The impact of the TD research 'intervention'

was given additional credence by the fact that the researcher was uninvolved in the case for a period of a year while researching the Austrian case as a benchmark study.

After a year away, the researcher was formally invited to join the TPOA and assist in implementing parts of the strategy that he had co-developed with them a year previously. It was clear, that even after a year their commitment to moving towards the goal of transforming technopark was tangible. This was evidence that a more formal and embedded SCI had been formed as a vision to achieve this. This allowed the research process to continue as a TD case study, but it also allowed for further first-hand validations of the case. The researcher's involvement in the TPOA continued until 2015, when the final research findings were recorded here.

7.10 SCIs within RISs - influence, direction and qualities of innovation outputs

The aims of this subsection are to provide evidence in the findings to answer the research sub-question: *2a. How do SCIs within RISs have an influence on the direction and qualities of innovation outputs in the regional/local economy?*

From discussions at the regional level there was evidence that the RIS, although institutionally quite weak, was being influenced towards a sustainability-orientation. The existence of Green Cape, at the time recently established as an intermediary, was part evidence of this. This government intermediary had a board of directors and an advisory council that consisted of academia, government (both national and regional) and industry partners who were strong proponents of sustainability (W.C. RIS T 2011). Through its presence and work in the province, Green Cape clearly enabled SCIs in the RIS move towards a sustainability-orientation. Its role was to actively promote 'green' industries in the regional economy to affect the RIS positively.

The researcher's immediate concern, through engaging with the case at the regional level, was the lack of communication between key actors in the RIS. For example, it was found that many role players were not aware of the DST's mandate to establish innovation forums (RIFs) in each province of South Africa. More alarming for the researcher was the lack of familiarity with the concept of a RIS, except for a minority of actors trying to drive it at the regional level (W.C. RIS Actor T 2011). One key actor, who was trying to enable restructuring in the regional economy, also had not heard of the attempts by a minority group

of actors (i.e. the interim RIF Steercom). This signalled a clear communication weakness at the provincial level and a lack of 'institutional' legitimacy.

W.C. RIS Actor V's (2011) conceptualization of the RIS was that it is embedded within a wider economic system. It was this actor's intention to build institutional capacity through the EDA to enhance regional economic development and with it the innovation system of the region:

> What is the business climate and investment climate, overall what are the gaps in the market, the needs to play in, overall what are the areas where better aggregation of effort will be required, overall how do we start to create an agenda that moves the whole thing [economy] forward. And I think that that's quite an interesting way to look at it. It is, as it were, the economic system that surrounds the innovation system.

Clearly, SCIs at the regional level had an influence and impact on the smaller scale levels like Stellenbosch. One of the intended aims of the EDA structure was to focus institutions to collaborate and support economic and innovation activity (RIS V 2011). This required SCIs to shift towards a certain ideological perspective of development for the province of the Western Cape.

Ideological and SCI disconnect were a direct cause of the 'institutional weaknesses' pointed to above, and were also related to spatial disconnectedness in the region. One of the primary issues was cognitive distance between the triple-helix elements in the RIS. According to W.C. RIS W (2011) economic decision-making by regional government was based on rigid SCIs of statistical analysis, and was void of any human-centred or systemic approaches to development. His view was that the relative 'failures' of the region's innovation and economic infrastructure arose from lack of understanding of the importance of spatial, social, cognitive and organizational proximities:

> But what they [Govt] completely failed to recognise is that businesses are collections of people and people are driven by emotions, they are driven by comfort, they are driven by faith etc. So you go and stick a science park out in Capricorn Park and it doesn't work. Well what a surprise you know. Miles away from anything, there is no public transport there is nothing there that would make it comfortable for people to base themselves there. Whereas 22@ Barcelona [Innovation District] concept is a very interesting one because first of all it is central; secondly a lot of it is making up a fantastic area to be. So people go out onto the streets and there are students and they have got learning institutions in there and they have got vibrancy in there, there are interactions, and there is rubbing shoulders and all of that sort of thing. Those are all human elements. It has nothing to do with the numbers.

This example shows the importance of the human factor in spatially-based innovation efforts like science parks. Additionally, according to the respondent, institutional and cognitive proximities were distant within the RIS, resulting in emotional decisions by individuals in positions of power, as opposed to collective decision-making between actors in the RIS

(W.C. RIS W 2011). This lack of collaboration, was also due to a lack of an institutional culture (and SCI) of trust between the elements of RIS. There was a clear need to incentivize collaboration and communication and create platforms to do so (W.C. RIS T & V 2011).

From the various responses and the findings it was understood that there was a definite need to enhance the closeness of all forms of proximity at the regional level as they were particularly distant:

> I feel that this (R)IS is almost to change mind-sets and the way people work, because people tend to work in silos and this is going to try and make them sort of mix work and foster those collaboration outputs through meeting.
>
> (W.C. RIS Actors R 2011)

At the time of the research, there was great difficulty in developing a coherent and uniform SCI at the regional level. There was considerable institutional instability between different power groups in the socio-economy. One of more influential groups in the RIS representing corporate business in the region was 'Accelerate Cape Town'. From the interview it was clear that their formal SCI was not at all focused on sustainability and their core focus was to enable and support socio-economic growth for the region (W.C. RIS W 2011). From the researcher's perspective, this was an understandable SCI, due to the need for creating jobs – environment came second. However, the notion that SCIs for sustainability can and should include both factors of environment and social development was missing. In other words, there was no evident recognition that new directions for environmental sustainability could in fact also create economic growth, and thus jobs.

It was clear that the EDA aspired to become a leadership organization, for institutional development in the region. The EDA, which officially became the Economic Development Partnership (EDP) in 2011, had a plan to create a joint vision for the region called ONECAPE2040 which provided avenues for institutional development to support not only economic growth but transition management in the province. This process was in the planning phase during the interviews at the regional level and was completed a year later in October 2012. The vision that was developed is: 'A Highly skilled, Innovation-driven, Resource-efficient, Connected, High Opportunity Society for All' (ONECAPE2040 2012).[50]

[50] (Please see One Cape 2040, 2014). While a review of this, work was not formally included in the analysis, it was taken into consideration in the analysis, and in the discussions.

Green Cape's perspective, shared by the researcher, was that a window of opportunity existed in the RIS to shift SCIs towards a sustainability-orientation due in part to the institutional 'instability' of the region. Green Cape's programme for enhancing knowledge about the green economy consisted of hosting stakeholder workshops, meetings with industry associations and various ministers. The aim was to get inputs into the direction of influencing the RIS towards a sustainability-orientation. Their initial focus was on renewable energy, which expanded to include other sub-sectors in the green economy. For example bio-gas, water treatment, solid waste treatment, wind energy and so forth (W.C. RIS Actor T 2011).

Stable and coherent SCIs in the RIS at the regional level were not present: they were considerably fragmented and siloed between elements in the RIS. The general SCI was not focused on SD, but primarily on economic growth, skills development and job creation. Despite these systemic weaknesses in the RIS, at the time of the research study, and through observation of the researcher after some time, it was evident that structures were being put in place to enable new SCIs for regional development. This included the efforts of Green Cape and the EDP in more recent years to create coherent institutions and clear direction for the RIS for sustainability. On the political level a promising programme called 110% Green[51], was driven as a campaign by the premier's office, From the perspective of the researcher this had a major impact on shifting SCIs towards sustainability in the RIS. Although there may have been some improvement in the stability of SCIs in the region, at the time of the interviews they were still fragmented and unstable. However, within this 'unstable' environment a strong SCI emerged around Green Cape promoting a sustainability-oriented SCI in the RIS.

At this point, the value that a sustainability-oriented innovation system could bring to the region in terms of socio-economic transitions to sustainability became clear. This is captured in the report that was written by the researcher for the Department of Economic and Development and Tourism (DEDAT W.C. RIS 2011). This report was later released at a public event with several regional RIS/RIF actors, who endorsed it. In 2013, which was some time after the report had been released, a decision was made to make the duty of 'high-level' governance and management of the RIS an EDP responsibility. The EDP created three institutional mechanisms to drive the RIS: the 'Regional Innovation Network' (RIN),

[51] 110% Green was an initiative by the W.C. premier's office to identify and publicly reward 'green' or sustainability initiatives that were contributing to the green economy in the region. The Stellenbosch Innovation District (SID), eventually also became one of the flagship projects.

'Improving Regional Innovation Systems' (IRIS), and as a mechanism to drive a sustainability-orientation called 'Green Innovation Network' (GIN)[52]. From the perspective of the researcher at the time, the efforts were commendable and certainly what the region required. However, fragmentation, power struggles and contestation as to the mandate of the EDP continued. There was also no policy framework to support the RIS at the time. Another concern of the researcher was that the Green Economy (which was being debated at the time) was seen as a sector of the economy rather than an overarching framework. Below are extracts of conversations by the researcher with actors in the RIS, about developing a sustainability-oriented RIS. The concept of 'bio-mimicry' was an example of a different kind of 'quality of thinking' or SCI in the RIS:

> In nature it is always a complete system that doesn't have any impact on the environment because it's well, nature. We need to learn how to copy from nature and I think Cape Town is the perfect location. We have open minded people here and I think that concept has caught on quite quickly and we have the potential now to include that into a mainstream (and document). And why not? It's being done overseas and if we want to get ahead of the times, we should think about that. Life cycle thinking of the product itself, when we design…
>
> (Researcher in discussion with W.C. RIS S).

The researcher's explanation of SCIs for SD in SoIS was:

> It's a model [framework], sustainability is a philosophy that we 'plonk' onto the economy, so it has to infiltrate every single system, every thought process, every knowledge system that we have, has to include sustainability and a new way of thinking and what my research is about is how do we change 'minds' or socio-cognitive institutions, and it's very academic terms but it's basically about thinking out of the box for sustainability instead of business as usual thinking. And that in itself is innovation.
>
> (Researcher in discussion with W.C. RIS 2011 V).

7.10.1 Fragmented SCIs and sustainability influences at the local scale level

In Stellenbosch, representing an important local scale in the RIS, SCIs were also very diverse and fragmented, informally and formally. The societal and community discourses that reflected informal SCIs in Stellenbosch were not cohesive. Generally informal institutions were distinct between communities, SCI structures were separated by different racial, cultural, socio-spatial and socio-economic statuses in the town. Technopark represented an upper class, or high-end socio-spatial business community in Stellenbosch. In terms of the various forms of proximity, elements in the RIS/LIS were distant from each other. Most noticeable were organizational, institutional and cognitive distances. Spatially, elements in

[52] www.wcedp.co.za

the RIS were close and signalled considerable potential for enhancing the innovative capabilities of Technopark and the town itself.

Socio-economic disparities between income groups in the town were considerable, and TP by contrast represented a high-income business community. In discussions with academic staff from the Sustainability Institute (SI), it became clear that Stellenbosch is one of the most unequal societies in the world in terms of the wealth gap. This may have been, and probably continues to be the reason for considerable social and political conflict in the town. There are extensive social sustainability challenges in Stellenbosch. The undercurrent of 'divisiveness' creates not only rifts of discontent between different communities, but also a culture of non-collaboration in the triple-helix. While the lack of coherent institutions for the functioning of the LIS was apparent, fragmented and competing SCIs hampered attempts to achieve new directions for sustainability. This was evident, in the programme 'Sustainable Stellenbosch' which was initiated by the Sustainability Institute (affiliated to the University), which struggled to build SCIs and wider institutional support for the project. Initially, the aim of the TTP project was to be a subsidiary project supported in parallel with Sustainable Stellenbosch. Due to a lack of momentum and buy-in, the Sustainable Stellenbosch project was converted into a publication, which contributed in part to the formalization of SCIs in the LIS for sustainability in the town; it included contributions from researchers at the University and local resident experts[53](Swilling *et al.* 2014).

In the analysis of the interviews using CA, the various SCIs of actors in the LIS could also be interpreted or inferred. In many instances, perspectives, opinions and attitudes were shared with the researcher about their views on each other, and on the issues of inter and intra organizational and institutional conflict. In some cases it was astonishing. From both the researcher's perspective and those of several respondents, these fragmented SCIs resulted in continuous social conflict, power struggles, blame games, politics and general societal discomforts (TPOA & Firm Q 2011; Firm G 2011). From the researcher's perspective this was detrimental to any process of institution building between or within the triple-helix. A probable cause of fragmented SCIs was the socio-spatial separation of various racial groups during Apartheid. It was surmised by the researcher that over the years of segregation the various racial groups and social classes had also developed distinct SCIs. After two decades

[53] The researcher, colleagues and his supervisor authored a chapter about sustainable business in Stellenbosch which included a description of the "Transforming Technopark" project (Swilling et al 2014).

of democracy, the SCIs of society remain heterogeneous and compete for dominant positions causing continual instabilities in the systemic functioning of the RIS. From the findings, it is suggested that these instabilities hamper established visions for sustainability to become institutionalized as formal SCIs in the RIS, thus crippling attempts at socio-economic transitions.

7.10.2 The findings of the TTP project and SCIs

In these findings, the pervasiveness of the issue described above as conflicting SCIs is unearthed as tensions in triple-helix relationships between the TPOA and the other LIS actors in Stellenbosch. In the wider socio-cultural arena of Stellenbosch, the TTP project represented an island in terms of being a wealthy enclave of business owners and building owners. From the perspective of the TPOA and the business community there, they saw themselves as an important economic 'engine' for the town (TPOA & Firm J & P 2011; Firm I 2011; TP Visioning 2010). Many of the TPOA had a particular issue with the municipality which they perceived as using TP's rates and taxes income to subsidize poorer areas in the town, but without providing the legally obligated services to TP first (TPOA & Firm H 2011).

> Paradyskloof doesn't have an owners association because the Municipality is keeping up the gardens and the roads and stuff. For some odd reason the Municipality neglect the infrastructure of Techno Park and I don't know why.
>
> (TPOA & Firm P 2011)

The municipality, who were legal owners in the park, provided a different SCI to that of the other owners. They admitted their 'faults' but were also obliged to represent the wider social structures of the town. In the mind of one respondent, the 'feeling' from the municipality was that there was some justification to the 'redistribution of funds' because of the injustices of the past. The municipal respondent was well aware of the problem, but due to a lack of resources their hands were tied (Govt & Int F 2011).

The purpose of having commented on both the wider regional scale and the local scale of Stellenbosch is to provide context for the micro structures that surrounded the TTP project. In this manner, the intricacies of the structural issues within the LIS can be highlighted as proximities and fragmented SCIs.

Despite the considerable weaknesses in the W.C. RIS and the Stellenbosch LIS, Technopark achieved a formalized SCI through TTP and the vision and strategy process which it initiated.

One possible reason for this was that the TPOA and wider TP stakeholders had common interests and shared a common goal. This was interestingly pointed out by a Municipal interviewee (Govt & Int F 2011). Initially, with the TPOA, the visioning process started off with members identifying with the common threat of 'non-service delivery' by the municipality: this was the predominant SCI at the start of the TTP process. Over the period of the study, the negative shared fears transformed into more positive visions for the future of Technopark as a new economic identity within the town and regional RIS. The SCIs of the TPOA thus progressed from a negative sentiment to a positive one through the process of visioning. From the perspective of the researcher in the TTP project, there was a definite socio-cognitive paradigm shift of individuals, and of the group as a whole.

SCIs in support of sustainability existed mostly in isolation at both the regional and local level within the RIS. A most important finding, for answering the research sub-questions, was that although SCIs for sustainability existed, they were often hampered due to the dysfunctionality of the RIS and LIS. This was again evident in the TTP process that provided a magnified perspective on the wider issues of systemic dysfunctionality in the RIS. For example, Firm O (2011) saw government as placing large legislative blockages in the way of sustainable innovations taking root. However, despite the more apparent dysfunctionalities and weaknesses in the RIS and LIS systems, there were surprising successes in developing SCIs through the visioning process in TTP.

As a starting point in the findings on proximities, it was clear that the triple-helix institutional distances were vast. There was little constructive collaboration between the University, the Municipality and especially the business sector in Technopark. The Municipality were defensive, because of the scolding tone of the business sector. The University seemed 'disinterested' and was a 'ship of its own'. And the business community was predominantly focused on making profit. Even though there was a formal agreement between the University and Municipality in the form of the Mayor-Rector Forum, it remained only a formality in the researcher's experience. Academic A's (2011) view, for instance, was that the University was spatially too distant to create any meaningful interaction with TP. In discussion with Academic B (2011), the researcher noticed that there was almost a singular view of collaboration for innovation – as entrepreneurship. What was required in their view was an 'incubator' in close physical proximity to the university. The researcher however, had an additional perspective of collaboration for innovation, which involved creating research

partnerships and interaction with researchers with existing businesses in Technopark, or elsewhere. These views of respondents were challenged by the researcher based on his knowledge of science parks internationally and university-industry relations in them. In response, Academic A (2011), suggested that what was required was an intermediary to link the University and TP. The starting point in building institutional collaboration would be through establishing a joint innovation fund. Programmes like the HOPE project however, signalled considerable potential for society-university research collaboration (or Mode-2 science in society).

The University's involvement with TTP, was primarily through InnovUS, and through one of their employees who attended the SISN events. The researcher was also in continuous discussions with this tech-transfer office during the years of research. One of the recommendations by the researcher to the TPOA and wider TP community was to consider an innovation centre that could be used as a multi-functional space for collaboration, incubation, administration and conferencing in the park. InnovUS had no objection to the idea, except that there was a possible conflict with their plans for an incubator on the campus of the university (Academic B 2011). Both ideas were feasible and would reflect a considerable improvement in the innovation infrastructure of the town (at least for entrepreneurship).

From the researcher's experience of engaging with both the University and the Municipality, it was clear that there were considerable cognitive and institutional distances in the proximities of LIS elements.

From a Technopark perspective, this institutional distance was also confirmed by several firms which saw little value in collaborating with the university (Firm G, K 2011). This was despite the nature of one business which was to identify skills gaps in the region for wind energy:

> So it's basically recognising wind energy, renewable energy, that it's the new industry in South Africa. We don't have engineers or artisans or technicians that can handle the actual project when they come online, so we're looking at what kind of training do we need to do, what type of school they need and what the curriculum should be, what kind of training programs they should encounter and what is the need. There has already been the determination of if we have to install so much capacity over so many years, how many people do we actually need to take and what facilities are there currently available where we can collaborate and use those facilities, so in the longer term establish a dedicated centre point.

Only one firm that was interviewed spoke of strong relations and interactions with the local University and other universities in the country (Firm O 2011). The researcher knew through

the TTP process that there were several other informal TP firm relationships with the university. However, this did not include any on-going joint research or formalized relationships. Neither did it include any sustainability-oriented directions, despite the strong research capabilities of the Engineering Faculty and the Sustainability Institute in this direction.

Part of the impediment to triple-helix institutional collaboration between TP and other elements in the RIS was the lack of any formal structure to drive this collaboration. TP and the TPOA was not yet a legal entity (even though it had been in the past when it was a science park) and did not initially see the benefit in re-establishing a relationship with the university. This view later changed as discussed with the TPOA in the extract below:

> I understand that you are trying to get a vehicle in place that can be a link between the University Academic Research and the practical needs from businesses and society to use that research
>
> (Firm P 2011).

In general, firms in TP were positive about the TTP visioning process. However, they remained sceptical about the possibility of achieving it. The various mechanisms available to bring it about are summarized below.

SCI and institutions – to achieve the TTP vision, it was suggested that there needed to be a greater focus on building institutional partnerships (Firm I 2011). It was suggested that for sustainability it was going to be about finding the capability gaps in the RIS for the green economy, e.g. solar and wind power. This was seen as part of institution building by sustainability-oriented Firm K in TP (2011). Building triple-helix institutions generally required connections between individuals with similar qualities who would be able to collaborate between elements in the RIS with similar qualities. This was a view of one of the respondents is based on the notion of cognitive proximities (TPOA & Firm L3 2011).

Mechanisms of the LIS – through investigating the TTP interview responses, and through reflection on his involvement in the case, the researcher was able to get a sophisticated sense of the mechanisms of the LIS. While Technopark was geographically located in Stellenbosch, its embeddedness in the LIS and the RIS was non-collaborative. It functioned in isolation from the rest of Stellenbosch, and firms within it functioned in isolation from one another, as the collaboration between businesses was poor. In discussion with Firm K (2011), the researcher's long term perspective on TTP was in:

> …trying to create an environment, which a firm can place itself into so as to enhance its internal innovativeness, because of an external environment.

The relationships not only between firms, but within the emerging triple-helix were siloed and disjointed and there was a need for informal networking to strengthen those informal ties according to Academic A (2011):

> to me what the prerequisites for innovation are, it's those what I call informal and loose networks of all the role players and you can only create that if you have firstly funding structure for research which encourages collaboration.

Both financing and knowledge production, two important mechanisms in the RIS, were quite strong in the LIS. In the TTP project it was revealed that considerable potential for these mechanisms existed, yet they were not functional. Most notable, was the need to strengthen the ties between firms in Technopark and the University.

However, the problem in the LIS, was understood from the perspective of Academic A (2011) as a lack of financing mechanisms, rather than physical infrastructures to support this kind of collaboration. In further discussions with University respondents, it was clear that large sums of money came into the university from the private sector for research and knowledge development. However, it was mostly from large corporates. For example SASOL, a well-known South African firm, provided funding towards the Centre for Renewable and Sustainable Energy Studies (CRSES) at SU's Engineering Faculty (Academic B 2011). A discussion with Firm G (2011), during the TTP process, suggested that transformation of Technopark towards a sustainability-orientation would require incentives to lure more 'green firms' to cluster in the park. If successful this would not only enable a spatial cluster, but could strengthen the competitiveness of firms due to closer proximities.

Knowledge production – in terms of knowledge production, as a mechanism in the RIS, huge potential was not being capitalized on. While research in 'partnership' with the private sector did exist, it was mostly one-sided research contracts with large firms. The private sector paid for research to be done by the university, for their benefit and too few cases existed where research was proper joint research with research contributions and dedicated capabilities from both sides. This was in stark contrast to the institutional structure of competence centres in the Styrian RIS, for example. Furthermore, an even greater opportunity for knowledge production was missed in view of the close spatial proximity of Technopark and the many SMMEs that existed there as possible partners in joint research. Knowledge production in the LIS, remained primarily a university activity and represented

the biggest missed opportunity for building innovation capacities in Stellenbosch. The almost linear perspective of the research–innovation system at the University of Stellenbosch was summarized by the Vice-Rector Academic 'A' at the time (2011):

> 'Innovation', I glibly call the process of taking knowledge to make money, in contrast to research which is taking money to make knowledge. In research you take money, you make knowledge – innovation is you take knowledge and you make money, that to me is the difference between research and innovation in a very simplistic way.
>
> (Academic A 2011)

The flow of knowledge production, within the LIS, and the RIS for that matter, was quite 'one-directional' and signalled a university push. This was institutionally reinforced within the University through the mandate of InnovUS, the technology transfer office, which was responsible for the limited role of 'commercializing university IP' (Academic B 2011). There was little influence and integration of university knowledge production with smaller scale business R&D, or joint projects in close proximity. While the local university prided itself on being a university engaging in 'Transdisciplinary' research, it focused primarily on social development challenges and had little focus on TD co-operation with commerce.

7.10.3 Proximities in the RIS and LIS

As already alluded to throughout the above section, proximities provided an excellent theoretical lens with which to analyse the TTP case study, and associated ethnography. It also provided insights into the reason for weaknesses in the RIS and LIS as distant proximities. TP was by definition a spatial agglomeration of firms in close spatial proximity. Yet there was little organizational and social proximity between firms and between individuals in the park. Firms G, K & I (2011) confirmed that the lack of social infrastructures where businesses and individuals could socialize was a major issue. The lack of social proximities went hand in hand with a lack of trust between organizations who were not keen to share their business knowledge or expertise with each other, despite numerous firms being in the same industry such as IT.

While there were few instances of close proximities between organizations within the park, there were also distant proximities between the park as a whole and the LIS/RIS. Although the park was designed as a science park, it lost this formal status in the late 1990's. As a result the park relinquished any formal management, and the only body that was established to begin coordinating activities was the TPOA in 2009. Again considerable potential existed, in re-establishing a formal entity for managing intra- and extra-park institutional and

organization relationships. This was only recently accomplished through the establishment of an NPC (TechStelSRA) to manage the park and begin to implement the future vision for the park. This includes both infrastructural considerations as well as marketing the park as an innovation or technology park.

In the TTP visioning workshops, it was also revealed that TP presented a considerable opportunity to become a new economic node in the town of Stellenbosch. For example, Govt & Int E (2011), who was in charge of municipal property in Stellenbosch, had his own vision of integrating the adjacent golf course, with the Technopark to become in his words *'The first golf course business park in South Africa'*. The environmental sustainability of Technopark, was also discussed in the visioning workshops, but also revealed by respondents in their desire to transform the park into an eco-friendly environment. Plans were in place to implement more comprehensive recycling systems, possible solar energy parking bays, to establish a consortium to connect directly to the fibre cables, and to possibly provide free wifi in the park (Firm I 2011). There were also discussions in the visioning workshops about the TTP becoming a showcase precinct in the town for sustainable and smart technologies. The aim was to create, learning opportunities for school children, students and researchers in the park, and to bring University activities into the park (Firm G 2011). This was aimed at enhancing collaboration in the park, and bringing cognitive and social proximities closer.

The vision of TTP, also included closer interactions with the universities, where informal research with firms in TP could take place. It was envisioned that this might stimulate localized learning for sustainability, especially if there were joint projects. During the TTP process, in fact the researcher did assist in getting a university student to do research on the ecological status of the dams in Technopark (For a pic see Appendix E5, of the dams of Technopark). The idea of promoting a strong vision for sustainability, through promoting TP as an example of a sustainable precinct in Stellenbosch was well received. The public acceptance of the vision, as well as the formalization of the TP NPC to adopt that vision and take it forward was tangible evidence and validation of transformed SCIs for sustainability. However, despite the strong movement for a new vision for TP, there was also considerable resistance from various individuals and institutions. They represented rigid SCIs of the kind that impede any transformation process.

Mini conclusion – despite some accord between academics for a sustainability directive, the general LIS elements and mechanisms of the town remain dysfunctional. There is no dominant or coherent SCI structure guiding the town towards a specific direction and formation of socio-economic development.[v]

7.11 Theme III – The micro- level and scale and embeddedness in the RIS, and NIS

The findings below contribute to answering the research sub-questions from the case associated to investigative theme 3a: *How do socio-cognitive institutions exist and how are they shaped by various forms of proximities on different structural and scale levels?*

7.11.1 National, regional and local scale

7.11.1.1 The national scale

As described in the introduction to the South African case, several policies that inform the NIS have an influence on the RIS and on the more localized innovation systems like Stellenbosch. The most recent vision and guide for South Africa was the National Development Plan (NDP 2013), which seeks to provide systematic goals for 2030. In terms of building national innovative capacity, the COFISA reports recommended that regional innovation systems become the new focus of development. As explained by W.C. RIS R (2011) there were several regional initiatives to establish 'regional innovation forums' in South Africa supported by the DST.

In terms of Science Parks, and engineered spatial innovation developments, South Africa has had mixed success (COFISA feasibility study 2009). From the researcher's perspective there is no fully-functional science park yet in South Africa. Not in terms of research co-operation with Universities, as compared to several international examples (mentioned in the literature review e.g. Emelia Romagna in Italy, or Shinshu in Taiwan). The Innovation Hub in Pretoria, in the country's administrative capital, is host to the only accredited Science Park in the country[54]. However, from the perspective of the researcher, the Stellenbosch Technopark, despite its unofficial status represents a more functional and innovative 'hybrid' technology park in terms of the mix of firms, and their innovative outputs.

[54] (www.theinnovationhub.co.za)

Science parks or innovation hubs, like TP were originally designed as intricate spatial components of regional and national innovation systems. They could be considered local spatially-based innovation systems. No doubt through their networks, they influence on higher aggregate levels.

7.11.1.2 The regional scale

The Western Cape RIS influences the Stellenbosch LIS more than the national IS does in terms of social, institutional, cognitive and organizational proximities. This is because, as revealed in the literature review, spatial proximity has an effect in shaping innovation-supporting structures. Thus the fact that Stellenbosch is spatially close to Cape Town, despite being under separate administrative control, means that it is heavily influenced by the city-region from which it is functionally inseparable.

Depending on one's critical stance or theoretical lens, both Stellenbosch as a town and the TTP case could be seen as an embedded part of the region's RIS, yet spatially separated. It is its own spatially-based local innovation system as well, with Technopark contributing a major innovative capacity within the RIS. Putting it into perspective, the Western Cape has a population of around six million, of which four million live in the Cape Town city-region (Census 2011). Stellenbosch University is one of four universities: one of the two which are ranked in the top 200 internationally, with a third ranked fifth in South Africa, and the fourth an 'up and coming' university of technology. By comparison, economically Gauteng is by far the largest region in the country, contributing more that 40% to the overall GDP. However, according to the Western Cape Provincial Economic Review (2014), and 'ONECAPE2040' the Western Cape is the most innovative region in South Africa, with the best research capabilities.

Through analysing secondary data and through primary interviews, the researcher's study of the RIS revealed there to be distinct 'operational' environments for the RIS at multiple levels, institutional structures and geographic locations. A governance strategy of the RIS for sustainability in the report suggested 'conceptual separation' between regional and micro spatial nodes, but also between macro, meso and micro structural levels. According to the RIS report prepared for DEDAT (DEDAT RIS 2011)by the researcher, this logic or reasoning was informed by: a need for macro regional innovation policy, sectoral innovation system governance or cluster management policy (i.e. structural support for the existing SPVs), and spatial agglomerations and spatial clusters of concentrated innovation and entrepreneurial

activity. There were several of the latter in the Western Cape, including the Fringe 'Innovation District' in the city centre, as an example. Stellenbosch and TP was another.

While the NIS played an important role at the regional level, in terms of financing and incentives for a sustainability-orientation (e.g. Jobs Fund contributing to the social sphere and the Green Fund for the environmental sphere)[55], there was also a reasonable degree of autonomy in financing from regional government and private sector structures. The W.C. RIS V (2011) was directly responsible for the development of the EDA, and part of their perceived mandate at the time was to support structural transformations of regional socio-economic institutions (i.e. regional scale–macro structure). The proposed EDA's and ACT's view of 'region' was the 'functional city-region' of Cape Town, which included Stellenbosch (W.C. RIS V & W 2011). Part of the considerable challenges of the 'region', which was very different to the Styrian region, was the dramatic socio-economic and developmental disparities in the Western Cape, which are also socio-spatially separate. Regional intermediary organizations like the proposed EDA, made this clear in their responses: 'we're trying to look at the systemisation of the whole system and what leads and what lags I mean, it's not easy' (W.C. RIS V 2011).

7.11.1.3 The local scale

For many respondents, the geography and the sense of place of Stellenbosch, as well as Technopark, made it one of the nicest places to live and work in South Africa. As one respondent replied in conversation with the researcher about the importance of Stellenbosch as a good location for business: 'Okay, what you are now saying about the environment, the social atmosphere is the biggest thing – location, location, location' (TPOA & Firm J 2011). Stellenbosch is surrounded by majestic mountains, situated in the heart of the Winelands, and is close to Cape Town, and the beaches. These geographic elements were understood and experienced by the researcher as providing a sense of 'ownership' of place in the SCIs of actors in the LIS. These subtle factors, like infrastructural access, two national highways in close spatial proximity, and the international airport of Cape Town 30 km away, enhanced the attractiveness of Technopark as a business and innovation destination. It was an attractive

[55] Other national financing structures for innovation, with regional offices included the Technology Innovation Agency (TIA), a newly established national support structure for innovation.; the THRIP programme, to stimulate research and industry collaboration; and various other funding options from the DTI's financing intermediaries e.g. Industrial Development Corporation of South Africa.

place to live and work, thereby attracting and retaining talent and capabilities for the LIS. Not many of the capabilities, however, were directly or explicitly sustainability-oriented.

The TTP project, the LIS and the RIS, were embedded within the national scale level of the South African NIS. Although there were no direct and formal NIS connections to Technopark, many of the companies that were resident in TP operated on a national and international level. These connections were lost when the park stopped being controlled by the university and municipality as a science park in the mid-1990s. COFISA's feasibility study of Science Parks in the W.C. came from a national structured programme to rekindle the concepts of science parks in the country. Technopark and Stellenbosch was one of the locations for the study to explore the possibilities of re-instituting it as a science park, and Stellenbosch as a spatial-innovation cluster. At the regional level, there was great interest in supporting and designing spatial nodes like 'innovation districts' (e.g. the Fringe project). However, as discussed with the CEO of Accelerate Cape Town, the human-centred factors, in conjunction with spatial factors, should be strongly considered. This view, including the importance of arts and culture, was reiterated by respondent Govt & Int (2011). Real-estate approaches to 'innovation spaces' have often failed in South Africa, due to the neglect of important proximity factors and networks. There has been a lack of understanding of the importance of various RIS elements, within these developments. According to W.C. RIS V (2011) it is leisure and comfort factors that retain talent, whereas neglect of the socio-cultural, spatial and institutional factors were possibly the primary reason for failure of the many Science and Technology parks attempted in South Africa. Capricorn Park, was in a 'disconnected' part of the city and thus also failed as a science park W.C. RIS W (2011). Technopark, failed as a science park for multiple reasons. Most probably due to a lack of any sort of market for it in the 1980s. However, it was also a misunderstood concept, and there remain challenges in bringing the SCIs between triple-helix partners closer together.

Technopark however, also developed in a different spatial and institutional context than the other failed science park referred to above. Although it failed as a 'registered' science park, it hosted key characteristics of an innovation hub and technology park. It had a good mix of tenants, that were producing some of South Africa's top innovations in ICT, solar energy technology, radar technology, water systems, geo-hydro engineering and satellite technology, and was home to the headquarters of the fastest growing financial institution in

South Africa In terms of businesses that were innovative and economically prominent, TP was a success.

Despite TP's local geographic scale, its organizational connections extended nationally and globally. Firms like I (2011) that were resident in the park were responsible for rolling out ICT infrastructure on a national and continental level. Stellenbosch was also home to several other national headquarters in fairly close proximity to Technopark, some in the park itself. Firm K (2011) for instance was an international sustainability-oriented company with its headquarters in Technopark. At the time of the initial interviews, there were only four sustainability-oriented companies in TP, some years later, a number of additional companies that could be classified in this way had 'clustered' in the park spatially. What was interesting from a researcher's perspective was why the organizations in such close proximity were not collaborating or interacting. The qualities of SCIs within social structures at different levels provided the clue, which is best described using the theoretical lens of proximities.

7.12 Multi- level macro, meso, micro structures and SCIs

Places like Technopark and Stellenbosch contributed and were connected to more aggregate SCI levels in the RIS. Yet, it was an isolated spatial node, which also influenced a specific SCI for sustainability in the town. The specific SCI was revealed as a vision and strategy during the TTP process, Stellenbosch, also operates to a large degree independently from the RIS. It has its own local government, its own university, its own research institutes, colleges, schools and its own 'hybrid' technology and innovation park. The point is, it is geographically separated from the greater city-region through a 'green-belt of vineyards', but is infrastructurally and economically borderless, as part of the wider city-region of Cape Town.

It is interesting to compare the relative geographical or spatial isolation of the local scale, to social, organizational and cognitive networks extending to the micro, meso and macro socio-structural levels. In simple terms, the LIS was spatially local, but socio-structurally it operated on micro, meso and macro levels of influence. Formal SCIs for sustainability for instance spanned to the national level through research activities within the LIS. Informal SCIs for 'TTP,' for instance, remained quite localized, but eventually grew to the national level in the formalization of the SID, which was supported by the DST.

Initiatives like the Sustainable Stellenbosch programme, and the TTP TD research served to influence the SCIs in the town on a micro level towards a sustainability-orientation. The researcher's insistence on developing a long-term vision for the sustainability of Technopark (and later Stellenbosch, through the SID) was a primary driver of shifting SCIs towards sustainability according to TPOA & Firm J (2011).

On a macro structural level, issues such as climate change, and the energy provision crisis in the country had major effects on the SCIs of actors in the RIS, at all structural levels (W.C. RIS R 2011). However, due to the already existing and formalized SCIs at the University, these sustainability-oriented SCIs began to slowly expand within the SCIs of actors in RIS elements. At the micro structural and spatial level, represented by the TTP project, the shift in cognitive frameworks of individuals and thereafter socio-cognitive institutional formation was apparent. At the meso level, and regional scale, despite the fragmented SCIs, there was evidence of strong pockets of SCIs that supported a sustainability-orientation in the RIS. Evidence of this was the establishment of intermediaries like Green Cape and programmes like 110% Green through the provincial government. At the micro level, most of the SCIs of actors in the park were at first fragmented, but at a later stage, via the visioning process, aligned with one another in various ways. What was noticed here is that building owners' SCIs were shaped by interest in enhancing and maintaining the infrastructure and service elements of Technopark. Their initial SCIs were very short-term-goal directed. Whereas the business owners' SCIs, were slightly more long-term, and concerned with the potential of how to re-imagine technopark as a vibrant space that would benefit them as individuals in their businesses. They were far more concerned with the future ability to 'connect' spatially to the rest of Stellenbosch and, particularly socially and institutionally, with knowledge centres like Stellenbosch University. The joint vision of these two stakeholders included the need for management of the park (TPOA & Firm P 2011). In the development of the vision, from the TPOA's side, there were definitely competing SCIs at the beginning of the process resulting in considerable social conflict among members. Most of the problems they had issue with were short term decisions that needed to be made. However, when it came to a longer term vision about the sustainability of the park, most stakeholders including the municipality, the university, the TPOA and business owners, could agree on a way forward. The common goal of Sustainability in fact became the common challenge that needed to be solved, but in different ways, and for different individual interests. This common goal created the impetus for driving the SCIs in the TTP process.

In the SCI shaping process at the micro structural and local level, understanding the phenomenon from a proximities lens provided good insight into its development. Spatial proximities certainly played a role in unlocking the potentials in bringing closer the other forms of proximity. For example, despite the initial organization, institutional and social distance between firms in the park and the wider town stakeholders like the university and municipality it was easy to create a 'gathering'. A spatial gathering, and meeting face to face, and the individual meetings with the researcher helped to build trust within the networks through the TTP process. The researcher found in listening to multiple individuals and groups' own visions for the future that there were considerable overlaps. The researcher often revealed these overlaps, as the point of departure when bringing 'conflicting' groups together. The overlapping elements of their SCIs is what eventually built an institutional SCI within the visioning process of TTP. Positive focus areas were used, rather than the negative 'sticking' points for finding common ground among conflicted parties. In addition, highlighting the future potential for Stellenbosch and for Technopark was experienced as the most potent power driver of change and formation of SCIs in the LIS (Firm J 2011). It was the aim of the researcher, and most of the stakeholders in TP, that the vision be achieved, and that a socio-cognitive momentum be achieved for that vision that becomes spatially embedded within Technopark:

> What I specifically focused on is creating a vision for a physical location, a geography of fate, which influences our thinking and shapes the way that we interact with each other. So the whole project is about us transforming Technopark into such a space.
>
> (Researcher in Discussion with SA Firm K 2011).

And in discussion with Firm K the researcher explained the vision as follows:

> And for business we've recognised that what would be is the next kind of infrastructure, but also the soft infrastructure such as creating a network between the role players in Technopark, clustering them in different areas a kind of industry et cetera. Linking them to the university, creating a channel for that link first of all, creating a channel for that link with the CSIR and sustainability institute and CHEC which is the Cape Higher Education Consortium, because in South Africa there is a problem of very low levels or low impact collaboration between universities and businesses directly. So my research is social research in the sense of how do we re-connect this Triple Helix Network, which is a model of innovation at the end of the day.
>
> (SA Firm K 2011)

Mini-conclusion – in forming the SCIs, actors within the RIS within their own minds developed ideas and steps for action. It created a new framework for the short-term tasks that in some cases were changed due to the longer-term vision. This is where the socio-economic transitions began to take place in development of the action plan and actual implementation

plans of TTP. The momentum of the TTP project and associated SCIs expanded to the whole town, to become a programme formally supported by the Department of Science and Technology. This was the Stellenbosch Innovation District (SID) which was driven as a 'next phase' project for the socio-economic transition of Stellenbosch towards a smart and sustainable town. This project had its own significant challenges, as the SCI surrounding this vision suddenly extended to include multiple other stakeholders in the town, with alternative SCIs.

7.13 Conclusion Part III

In Part III, two case studies and their findings were presented. The purpose of which was to gain a rich understanding of the narratives contained in each of them about regional economic development and the potentials of innovation for sustainability.

The Styrian case represented a transition from a relatively weak regional economy, with large, polluting state-owned enterprises in the 1980s to a region that is known as one of the world's most sustainability oriented. This case traced the formation of socio-economic change, via the narratives of respondents who had experienced the shift in their lifetimes. Many of them had been a direct part of the change in Styria towards a more sustainable trajectory. This was either individually as innovation champions, or through their organizations, the Styrian government and Stryian firms. While the socio-economic 'transition' to sustainability is still taking place, the study considered part of this period from the 1970s – 2010s. Substantial progress has been made in shifting their economy, and in implementing systemic change in their society for sustainability.

Out of old dirty industries grew a new innovation and knowledge based economy that is recognized as one of Europe's most competitive. Interestingly the clean-tech sector grew as the fastest sector in comparison to other sectors. This signaled from the perspective of the researcher a growing global demand for sustainable products and services, since Eco-world exported more that 80% of these products and services. This sector grew from multiple 'backyard' projects and experiments to hundreds of multi-national companies servicing the growing international demand. However, the home-market or endogenous growth and shifts within existing industries during the 1990s spurred this growth towards a greener economy.

The SCIs of the Styrians and the elements contained within their RIS, was largely driven by a strong societal pressure and identity to 'do what is right'. The environmental movement, later

becoming a sustainable development focus, was strongly driven by the region's knowledge systems. Both private sector research, and public research institutes, of the five universities in the region contributed significantly to formalizing SCIs which shifted the RIS, and thereby socio-technical systems and the economy towards a sustainability orientation.

The South African case was different, because the region of the Western Cape could be equated to how Styria was in the 1980-90s. How it was, in terms of the level of organization and sophistication of its RIS. The W.C. shared a similar status in terms of its excellent research capabilities at the four universities in the region, but fails to make strong connections with SMMEs. Governmental support of intermediaries which were fundamental drivers of change, and systems builders was concerning. However, there were signs that the kind of hybrid triple-helix organizations were sprouting. The W.C. is also regarded as a region with huge sustainability challenges, especially in terms of inequality and unskilled labour, and migrant workers who place stress on existing infrastructures. The challenge of sustainability is largely viewed as a social one.

The South African study was focused on the existing conditions and the quality of RIS relationships between triple-helix role players at both the regional and the local level. The local level project 'Transforming Technopark' exposed the inner functionalities and dysfunctionalities of the wider RIS. There were clear challenges of disconnect between elements in the RIS, and most notably so between the local government, university and firms in Technopark. The Technopark, and its owners association, represented one segment of society with a particular SCI that was perceived by several other SCIs as 'non inclusive'. This was not the perspective and experience of the researcher, however, who understood the needs and the challenges of an infrastructurally dysfunctional Technology and business park. There was a need, however, to build institutional bridges through creating spaces for shared visions, and for building trust within the LIS.

The embeddedness of the research in the RIS, and LIS, allowed for extensive time observing the perspectives of various stakeholder groups. What was promising was, and what the researcher discovered was, that there were large overlaps in the SCIs of the 'conflicting groups' in society. When the researcher, in the investigation process spoke to each group independently a better perpective was gain of each group's visions for Technopark. Most actors wanted the same thing, and this was publicly concluded in the visioning workshops. It was the smaller issues, and social politics, and power games that hampered progress to build

a unified vision and functional LIS. Through the TD process, the researcher was able to build trust, in the networks and collectively through time a vision was socially constructed for TTP, and has been adopted. This transdisciplinary process discovered significant hope in building the required social conditions for effective innovation system functioning in collaborating with the various stakeholders. Furthermore, the strong intentions, and passion to find solutions for social sustainability challenges, were drive by a powerful SCI and identity to progress South Africa as a whole. The notion that it could begin in places like Stellenbosch and Technopark, were not take lightly, and further encouraged mind-shifts and vision building for the future.

While the Austrian case focused, through the orientation of its SCIs largely on environmental challenges, the South African SCIs within its RIS was largely focused on the challenges associated to human development. Sustainable development certainly meant quite different things to the various actors and leaders at the regional levels and local context of two different nations globally.

PART IV – *Chapter 8*

SoIS, discussion, conclusion and recommendations

Chpt 1 – Introduction to the dissertation

Introduction - *the dissertation's argument is outlined here, defining the notion of socio-cognitive institutions as inherent in innovation systems.*

Chpt 2 – Defining and contextualizing innovation, and innovation systems

Chpt 3 – Sustainability transitions

Part I – *An extensive literature review of innovation, innovation systems and sustainability transitions. Arguments about the complementarity of the literature is made in lieu of achieving sustainability transitions via an ISs approach.*

Chpt 4 – Design, development and presentation of the content analysis framework

Part II – *The literature review is converted into a deductive content analysis framework for the case studies, with a critical discussion of it. Methodology and methods are discussed.*

Chpt 5 – Introduction to the analysis process of case studies

Chpt 6 - Case 1 – SCIs, the RIS and socio-economic transitions of Styria (1970 – 2010)

Chpt 7 - Case 2 – 'Transforming Technopark' in the Western Cape Regional Innovation System

Part III – *An introduction to the organization of data, and coding procedures are given. There are four levels of analysis of each case study. Including coding of data texts from interview transcripts, inductive interpretation resulting in new categories or findings, ethnographic interpretation by the researcher as a narrative, and finally the researcher generalizes patterns in the findings. Each case was distinct, but collectively they contribute extensively to novelties in understanding the role of socio-cognitive institutions within ISs and STs.*

Chpt 8 - Discussion of the findings in the context of STs

Part IV – *this is the culmination of reflection on the findings of the case studies back to the research questions, so as to answer them. Recommendations for future research are also given.*

Part IV – Chapter 8

Context in dissertation: *Part IV concludes the dissertation by answering and commenting on the research questions, by bringing together theoretical insights together with the findings of the research. The opinion of the researcher on the various investigative themes are provided for, and lay the foundation for future research and policy recommendations.*
Aims: *The primary aims of part IV are to provide a brief summary of what has been covered in the various topics of the investigative themes and the dissertation as a whole. This ranges from theory to the findings of the case studies and implications for future research in the field.*
Primary argument and logic: *It is asserted that sustainability-oriented ISs (SoIS) are the best possible tools for understanding and building capacity for sustainability transitions. Future recommendations also suggest that the spatial dimension in fostering geographic nodes of change for sustainability should be urgently considered in policy and practice, globally and in South Africa.*

Dissertation orientation for Part IV

This dissertation boldly asserts that innovation systems (IS) are the conceptual tools best suited to achieving sustainability transitions (STs). However, they require the correct configurations to ensure this. What makes ISs sustainability-oriented is not yet known. However, this dissertation attempts to uncover at least one perspective – that of the contribution of socio-cognitive institutions.

A number of purposes and aims are discussed generally here, and then also specifically listed in this final part of the dissertation. The overarching purpose is to bring all the arguments presented in three separate investigative themes together in answering the primary research question of the dissertation. What follows is meant to provide a commentary on each investigative theme in the context of the findings and in the context of sustainability transitions. Where appropriate in the discussions, comparisons are made between the two cases. In commenting on the cases, a brief summary of the generalizations as they relate to theory are provided. Attention is also drawn to the inductive findings that provide new insights into the theories of RIS and STs.

In brief, the primary aims of part IV are to provide a brief summary of what has been covered in the various topics of the investigative themes and the dissertation as a whole. This ranges from theory to the findings of the case studies, various challenges experienced by the researcher and implications for future research in the field. The contribution made by the dissertation from an innovation systems perspective is also highlighted. These are the reasons for doing so:

a) To reflect on the findings of each case study, in context of ST theory and practice. The aim is also to provide a critical view of the limitations of the deductive analytic framework, through the inclusion of inductive findings of the analysis. This aims at the development of theory towards sustainability-oriented innovation systems.
b) To discuss the aims of the dissertation, and provide a final answer to the primary research question, through a reflection on each research sub-question within the context of each investigative theme.
c) To introduce and lay the foundations for a theory of sustainability-oriented innovation systems as a novel approach to achieving socio-technical and socio-economic transitions to sustainability.

d) To conclude the dissertation from the perspective of the researcher and thus provide an overview of what was discussed. This is done through a brief explanation of the most important aspects of this dissertation. This includes a discussion on the general experience of the researcher and the challenges the researcher faced in doing the research.

e) To provide new directions and avenues for research based on this dissertation.

8 CHAPTER 8 - Discussion of the findings in the context of STs

The purpose of this section is to discuss and generalize the findings of the case studies in the context of sustainability transitions. To do so and to ensure congruency, these discussions will first be presented as feedback for each investigative theme. Thereafter, a more general response to the research question and the aims of this dissertation are discussed. Following this, some comparative examples between the cases are given, but it was not the primary purpose of the study to compare the two cases. Rather it was to gain two perspectives from two different sets of findings, from two different global contexts. The main goal of investigating two contexts was to gain a balanced historical perspective on a region that has achieved a measureable degree of socio-economic transition and clear dynamic perspective on a contemporary case that has a way to go before it achieves socio-economic pathways to sustainability. In addition, the two contexts represent two perspectives: one of a developed country and another a developing country, in relation to the common challenge, and sub-challenges dealt with in this dissertation:

The general problem statement can be summarized as:

Socio-economic pathways need to shift course to achieve sustainability, and there is little understanding of how SCIs within ISs may enable or hamper this shift.

In gaining perspective on this research problem, a main research question was posed as:

How do SCIs within RISs constrain or enable pathways to socio-economic development for sustainability, in turn affecting socio-technical transitions to sustainability at different structural and scale levels?

The three investigative themes of this dissertation were used to answer the primary research question related to the research problems stated above. By bringing the various problems, arguments, and research questions together into a coherent and final argument, it is possible to explore the role that ISs may play in enabling STs in different spatial contexts and structural levels.

While the findings in Part III provide the evidence for the answers to the research sub-questions 1a, 1b, 2a, 2b and 3 for each case, here they are reflected on and discussed in the context of both cases. This includes the additional insights gained from the inductive analyses

that were conducted. While the inductive perspectives were already woven into the narrative provided in Part III, here they are made more explicit in relation to each investigative theme. This allows novel insights to emerge that may contribute to generalizations for theory development and policy recommendations. In the discussions of the theme, the emphasis is placed on an ISs approach to sustainability transitions.

8.1 Reflection on the case studies and experience of the researcher

The primary difference between the Austrian and the South African cases is that the former is a retrospective and historical study, whereas the South African one is a contemporary case study. Both cases were presented as ethnographic narratives from the experience of the researcher. However, the narrative also includes the voices of the interviewees, who are often quoted directly. This ensures a degree of authenticity, and provides direct responses to themes and research sub-questions in several instances. The nature of the two case studies, however, remained quite distinct. The key experiences of the researcher, including challenges faced in each case are presented below. The perspective of the researcher and the narrative of the experience is deliberately more pronounced in the South African case.

The 'Transforming Technopark' project was a transdisciplinary case study involving the researcher as a participant and an observer. The TD approach, was a novel approach to doing research at a PhD level at Stellenbosch University. Adopting this methodology and approach was challenging, due to the requirements of co-defining and developing problem frameworks with which to do the research. In the end the researcher, followed a consultative, transdisciplinary approach (Mobjörk 2010) to the case study. This allowed for the researcher to consult various participants, in making decisions about the research focus. Using this approach, it was not necessary to build an overarching consensus between academic and practitioner perspectives. Rather the researcher took their perspectives into consideration in building the general problem framing for the research. Due to limited resources it was more appropriate for a single researcher to act as a consultant to the various participants. In addition to a transdisciplinary approach to co-developing solutions and a vision for TP; it allowed for an excellent insider perspective on the local social interactions that took place in the case. Gaining the 'insider' perspective was in itself a challenge for the researcher, and as mentioned ganing trust of the participants was a difficult and laborious task. The intentions of the researcher were intesely scrutinized by the case participants, due to past issues of 'control' of the park.

What is revealed in the findings is limited to a summary of the most important findings and discoveries from the perspective of the researcher. The views canvassed include not only Technopark stakeholders but also the wider stakeholders of the Stellenbosch local innovation system. And there is a broader perspective. The researcher was able to gain additional perspectives on the TTP project through his involvement in a regional innovation systems strategy development process. Through this he was able to gain knowledge, first hand, from a variety of actors, providing a range of expert opinions on the status of the W.C. RIS. Final commentary, perspective and recommendations from the researcher on each case are given only after feedback from the local and regional actors on each investigative theme is provided.

The Austrian case was relatively straightforward as it did not require the researcher to investigate contemporary and future scenarios or social processes as was required in the South African case. Instead the Styrian RIS and its shift towards a sustainability-orientation was the primary focus of the investigation. It ended with the contemporary RIS and its functioning and began with a historical perspective on the Austrian progress from the late 1970s onward. The Austrian case proved to be ideal for providing perspectives and findings from a region that had already accomplished a considerable shift in its economy towards sustainability.

No doubt some challenges were experienced by the researcher in doing the research. This included a bit of a language barrier, as many of the participants were not fluent in English. Other challenges included some reluctance by some of the participants to conduct interviews. However, the majority of interviewees were most willing to provide honest information for the purposes of the research.

Having the perspective of a developing country RIS and a well-developed and functional RIS to provide a rounded perspective improves the legitimacy of the findings. From the researcher's point of view, the contemporary W.C. region bears a striking resemblance to the Styrian RIS in terms of the challenges it faced during the 1980s: high levels of unemployment, pollution, strong but disaggregated and siloed knowledge systems, and overall systemic weakness. The positive outlook is that considerable efforts are being made in the W.C. RIS to identify the challenges facing the system, and to find constructive means of governing the RIS. Before the research was conducted at the regional level, the RIS (through the RIF) was only starting to be conceptualized. Today the RIS is backed by a dedicated

intermediary to drive the improved functioning of the W.C. RIS. In both cases, however, more could be achieved in terms of transformation or transition towards sustainability. There is considerable pressure on the environment as a result of unsustainable socio-economic activities. Sustainability challenges in South Africa require a greater focus on societal problems. Thus sustainability-oriented innovation systems should by default include the notion of 'inclusiveness' in them.

8.2 Discussion of findings Theme I

The aim of investigative theme I was to gain a better understanding of how stronger and more functional ISs have a better chance of creating socio-economic change in society, and along with it, socio-technical change for sustainability. Of course, stronger is not necessarily better if the IS resists adopting a sustainability orientation, but it is clear from the findings and the case studies that weaker ISs struggle to transition to sustainability at the speed and with the efficiency that is required. The implications for the developing world and the entire planet are considerable. Innovation systems need to be strengthened as a starting point, if SD and the more directed sustainable development goals are to be achieved. A more theoretical discussion to answer the two propositions related to this theme ensues.

Sub-P1a: ***Strong and functional RISs have a greater capacity to enable socio-economic transitions to sustainability.***

Sub-P1b: ***Weak RISs, have less capacity to produce and diffuse innovations, and hence enable socio-economic transitions to sustainability.***

8.2.1 Innovation systems, their strengths and functionality are vital for STs

Strong and functional innovation systems and their capabilities are extremely important for sustainability transitions. What was found in investigating the Austrian case was that, although strong and functional, ISs do not determine their focus or direction – they are geared towards solving problems in society. Innovation *per se* is about identifying challenges in society (through research, or search), solving them (through prototyping and entrepreneurship) and commercializing them and diffusing them in society. All these processes of innovation are social.

The system of innovation that functions within a nation, region or locality is the key to unlocking the potential for rapid sustainability transitions (ST). The speed of transitions to new social, technological and economic systems is of direct importance to achieving

sustainability. As Geels (2002) makes clear, what is required is a factor times-ten shift in the sustainability effectiveness of wholesale change in production systems (e.g. energy-input reductions, emission reductions). However, to effect such a rapid change in socio-technical systems on the ground, their motivation needs to be economic as much as it is ethical. Socio-technical transitions to sustainability need to make economic sense. Therefore transitions to sustainability should include the broader category of socio-economic transitions in parallel with socio-technical ones. As was discovered from the Austrian case, this is what happened in practice between the 1980s and 2010s. There were simultaneous changes in socio-technical systems on the ground (technological and infrastructural changes) and in the more socio-structural economic system changes towards a sustainability-orientation (i.e. with the growth of Eco-world cluster as an example). It is the re-configuration of ISs and their governance mechanisms that will lead to rapid sustainability transitions. Figuring out exactly what those configurations are, and how they could assist in the governance of ISs towards more sustainable directions may be the most urgent challenge of modern economic theory, policy and practice. This dissertation accepts this challenge by starting with the assumption that SCIs are one of the primary influences, or configuration mechanisms, and need to be understood in the context of ISs.

As discussed in the findings of the Austrian case, dramatic socio-economic shifts took place in the 1980s. In true Shumpeterian fashion, creative destruction of big, old, incumbent and locked-in industrial complexes made way for smaller dynamic and more innovative firms. The country was able to recover spectacularly from the breakdown of this socio-economic system. In the opinion of the researcher, this was due to the strength of its innovation system elements. Even though these elements were not well connected, and not functioning as a system, they were able to be independent. In the Western Cape of South African this was also found to be the case, but additional social and institutional weaknesses mar the effective functioning of the system. In Austria it was the strength of the knowledge system that was the key factor in the effective socio-economic transition to sustainability[56].

Even though the Styrian RIS was not fully functional as a system in the 1980s, the elements and mechanisms of it were strong in isolation. Finance was available, and the powerful and deep knowledge generators of the five universities adapted to the new socio-economic

[56] This is an on-going socio-economic transition, and is not complete. Yet in terms of socio-economic sector development, Eco-world represents a part of the socio-economic transition in the regional economy.

circumstance. The universities rose to the challenge and focused on providing a new kind of knowledge that met the needs of the service industry. Innovation and knowledge infrastructures (competence centres) developed on the geographic and institutional periphery of universities as a result. There was thus a powerful shift in the 1980s towards mode-2 science and university-industry relationships. The transdisciplinary and mode-2 knowledge approach and the openness of the universities to change (led by the technical ones at first) assisted smaller companies to become viable and more competitive. They also assisted those start-ups or projects in industry that were sustainability-oriented. In many cases they provided the fundamental research capacities that were not yet viable for the private sector to invest in. The focus of universities in the Western Cape is in the process of 'very slowly' shifting in a similar direction – which is good for economic development. From a sustainability-oriented point of view, the shift is directed toward developmental challenges as 'science for society' rather than 'science for industry'. A balance between developing knowledge for developmental and societal challenges, environmental issues and economic growth has not yet been achieved.

However, what is important to recognize in the example of the Austrian crises is the ability of the ISs not only to adapt to the challenges, but also to create opportunities out of them. Many of the solutions for sustainability, developed in the Austrian case, came from the bottom-up grassroots movements. They came from leaders, innovation champions, entrepreneurs and individuals. These individuals may have had the vision, but they had never innovated or started their business in isolation. The examples of bio-diesel, the wood-chip boiler and the solar heating systems all began with tight knit social groups who had a genuine interest in solving sustainability challenges and using local resources. However, the success of their innovations was not achieved in isolation. It was through a network of support of actors, mechanisms and elements of the RISs surrounding them. These 'resources' and required capabilities were easily accessible. The ISs support may also have extended from a local level to the regional, national and even international level (e.g. in the knowledge required to set up a waste system). In the South African case, the entrepreneurship support systems at the time of the TTP case study were regionally weak, but they improved dramatically over the period up to 2015.

A very important conclusion of this dissertation is that only strong and functional innovation systems have the ability to support innovations that can lead to STs. Strong and functional ISs

create opportunities, they solve challenges and usually have the ability to implement and diffuse them in society as well. There is also of course the issue of social acceptance and diffusions of innovations that are created. As is described in Roger's work, it is essentially a social process. If society is fragmented and innovation systems are institutionally weak, it is unlikely that innovations will be accepted or implemented as socio-technical solutions – albeit not as rapidly as those places with stronger institutions precisely aimed at implementing and adopting innovation through social learning.

8.2.2 Weak and dysfunctional ISs are a major constraint to achieving STs

Weak innovation and dysfunctional innovation systems severely hamper the likelihood that STs will occur in a region. This is because weak and dysfunctional innovation systems are: in the *first* place, not able to research, search and develop alternative solutions to existing unsustainable socio-technical systems; and *secondly*, often lack the institutional capabilities and systemic cohesion to test, implement and diffuse these alternative innovations in society. In the generalizations from the findings of the cases that follow, some examples are provided.

Systemic connections between the elements in the RIS, and most notably the knowledge system, are vital to the effective and rapid discovery and development of solutions to challenges in society. The socio-economic transitions required need to be achieved far more rapidly than current trends show. This requires strong, flexible and sustainable innovation systems. Rigid, locked-in and unsustainably oriented ISs, although strong, ultimately drive development in the wrong directions and prevent the system from addressing key challenges. In the context of sustainability-oriented innovation systems these systems are seen as misdirected ISs.

However, for ISs to shift internally to become more sustainability-oriented there has to be a shift in SCIs and in associated informal and formal knowledge systems both internally and externally to ISs. As a first point, universities and research institutions need to focus their attention more directly on gaining a better understanding of what those sustainability challenges are. The shift in academic knowledge systems towards transdisciplinary research is a very positive sign, but it is happening too slowly – in both Austria and South Africa. Knowledge from TD processes should be developed into usable knowledge that is transferable not only to society in general, but also to industry. This is because industry and firms are the 'final innovators' and also the primary 'implementers' and 'diffusers' of innovation. Most businesses exist because they are providing some form of value to

somebody somewhere. To achieve better and more sustainability-oriented value in society, they need to be able to tap into knowledge systems that are sustainability-oriented.

As a starting point and for sustainability transitions to occur there needs to be knowledge available that is sustainability oriented. In the Austrian case there were strong signs of this in the contemporary RIS, in the South African case, there was some, but it could be dramatically improved (especially in university curricula). Approaches to knowledge generation and research like transdisciplinarity (TD) approaches should encourage this shift towards a sustainability orientation. Transdisciplinarity is important because it often captures what society knows and universities do not know. In the Austrian case, it was suggested that societal pressures led to curriculum development for sustainability at the Graz University. Similarly, businesses or NGOs often know better than many academics what the challenges in society are. Solving sustainability challenges more effectively, however, requires research: not in isolation, but in collaboration with those who stand to benefit from the results – mostly industry, or entrepreneurs. In short, the knowledge that is generated by the available knowledge systems needs to shift dramatically towards a sustainability-orientation. Innovation systems need to use this knowledge to generate solutions as partnerships between their elements, e.g. between universities, firms, government, NGOs and various other intermediaries. Knowledge generation for sustainability is key. Weak ISs, however, may struggle with achieving a balance between environmental, economic and social issues.

There are problems in shifting knowledge systems in strong RISs too. One example from the Stryian case illustrates the lock-in effect of too close institutional proximities in their university-industry knowledge system. The direction of knowledge systems towards sustainability should be finely balanced between mode-1 knowledge and mode-2 or TD knowledge. As was shown in the Austrian case, there is a danger of university knowledge systems becoming too dependent on industry financing. In the short-term this is good, because it creates more immediate solutions for industry needs, and it creates jobs. However, in the longer-term it may also lead to continuous improvement – which is not good enough to achieve the factor 10 improvement for STs, as suggested in the literature (Geels 2011).

Thus there needs to be a balance in the financing of the production of knowledge at universities. This balance needs to be carefully monitored by the knowledge institutions themselves and through responsible leadership by government. Transdisciplinary research

programmes, with balanced university and private sector participants and interests, provide an excellent methodology to do so.

In the Western Cape case, however, while universities enjoy a reasonable degree of financial autonomy, there is not a good balance in terms of university-industry partnerships and financing of joint research. In other words, for economic sustainability, the type of knowledge generated could improve, or their capacities to do so could be enhanced. This was perceived to be a major gap in the system, and a considerable weakness of the W.C. RIS. The university system requires considerable development before the institution of knowledge production becomes more applied in a business direction. There is considerable room for improving this situation by considering mechanisms to enhance SMME and university relationships. This could be done through various means, possibly through enterprises similar to the competence centers that developed in the Austrian case. The opportunity also lies in ensuring from the outset that these centers take the lead in adopting a sustainability orientation.

Now that the first point is made about the ability of ISs to identify, recognize, research and part-develop solutions to sustainability challenges from a knowledge perspective; the second point is about their further development into innovations and their diffusion within society. Whereas strong ISs most often have this ability, weak ones do not, and may struggle not only to develop innovations, but to diffuse them in society. It is the diffusion and adoption of sustainability-oriented innovations in society that leads to socio-technical and socio-economic transitions. The discussion below provides examples, highlighting the problems of weak ISs.

8.2.3 Weak ISs hamper the ability to transition to sustainability more rapidly

While a good knowledge system, provides the ability to co-identify and do research on challenges for sustainability, another set of systemic capabilities is required to further develop these into innovations. A weak IS in the first instance may struggle to identify and provide knowledge about these sustainability challenges. This may be due to weak knowledge systems, or capacity gaps within ISs to identify and do research and develop the potential for innovation. Compounding this issue, in the context of weak ISs, is the issue of lack of capabilities, and systemic weaknesses in the further development of pre-developed solutions as research. If there is not a good bond or interaction between knowledge systems and production systems (in the Lundvallian sense) development is hampered. For such a bond

to develop, institutions, both formal and informal, need to be effective and have complementary goals. Innovation systems by definition need to be concerned with the diffusion of the innovations they create. In different contexts of regions especially, varied socio-spatial and institutional complexities may impede ISs from 'functioning as a system'. This was certainly the case in the South African IS, W.C. RIS and Stellenbosch LIS.

When ISs are disconnected and the institutions that need to support their systemic functioning are not able to do so, there are severe impediments in the two processes of innovation creation and diffusion that define ISs as described above. In the first instance, weak ISs struggle to identify, know, and do research on the required or (socially) recommended challenges. Secondly they struggle to develop the research into usable science. There is often too much distance of 'various proximities' between university-produced knowledge and its intended beneficiaries. Thirdly, the inefficiencies in the systemic functioning of ISs (like siloed thinking) reduce their overall effectiveness in diffusing innovation in society that can lead to solutions for sustainable development.

For example, in the South African case, there were considerable strengths, and most notably so in its knowledge systems; but it was also isolated from the other elements in the RIS. Knowledge was not generated in collaboration with the other RIS elements in an effective way and therefore the RIS and LIS did not function well as a system. The institutional support mechanisms were weak and not compliant. Institutions, firms and organizations although excellent in many respects mainly operated in siloes. The connections between the various elements of RIS were therefore systemically weak and dysfunctional, and most noticeably so between the triple helix of government, industry and academia. This was strongly observed and revealed in the 'Transforming Technopark' transdisciplinary case; but also at the regional level of the W.C. RIS.

From the researcher's perspective, there were several reasons for this. The most noticeable being the dearth of intermediary organizations, and the lack of government leadership and support for the effective functioning of the system. Instead, the elements of the RIS and LIS often stood diametrically opposed to one another, locking-out any effective form of collaboration. Again, from the researcher's perspective, there were good reasons for this which could be understood from a socio-cognitive institutional perspective. In short it was a clash of formal SCIs, as long-term ideological differences stemming from a past of spatial and socio-structural segregation. The Apartheid society was a siloed one and trust between

the different racial groupings has not yet been established firmly in South African society. These are deep structural issues of SCIs that continue to impede effective systemic functioning of the W.C. RIS.

However, despite these weaknesses, there were not only signs of change, but through this research potential avenues for change were discovered and are being supported. The research in this study provided one small example of what can be achieved through the process of joint-visioning, and through TD research. The TTP process revealed the full potential of developing functional ISs at least on the micro scale. Other promising signs of institution building for more effective functioning of the LIS and RIS became evident in the case. In Stellenbosch, it was the extension of the specific SCI around the town becoming an innovation district that was most encouraging, as it could potentially develop into a showcase for the wider changes needed for ISs to function successfully.

At the time when the study was completed, the Stellenbosch Innovation District (SID) represented a project that could significantly enhance the possibility of a sustainability-oriented LIS. The vision of a sustainable and innovative Stellenbosch had spread into the institutional mind-sets of leaders within the Municipality and University of Stellenbosch. They independently initiated their own programmes to support innovation and sustainable development.[57] However, despite these marginal successes in developing a vision for sustainability and innovation for the town, it was not without considerable conflict. This conflict will inevitably continue, and may derail the gains made from the project and its vision. As long as the SCIs of various socio-spatial and cultural groups continue as competing ideals, each undermining the other, any tangible efforts for STs will be slow. What is required is collaborative triple-helix leadership to remedy the issue, not only in the Stellenbosch LIS and W.C. RIS, but across South Africa.

8.2.4 Strong ISs are a necessary condition to achieving sustainability transitions

Strong innovation systems, as discovered in the findings, are already designed not only to find challenges in society but also to solve them. This is normal for any innovation process in fact, as innovations are usually improvements and provide some kind of change, whether it be incremental or radical. Therefore, it could be argued, that strong ISs by default direct their

[57] For example the Stellenbosch Innovation Capital project, as a municipal response; and the recently opening of a University incubator called LaunchLab that has one of its primary focus areas on 'green and sustainable' technologies.

research capabilities (e.g. via universities), and search (e.g. via industry) towards solving challenges and problems. Universities are naturally inclined to direct their research attention to challenges in society, and the private sector is naturally inclined to develop solutions that are best regarded as useful by society. Innovations that do not yet exist as products in the market or in society are usually diffused through existing business channels to consumers. Novelties, as alternatives to the 'mainstream' require entrepreneurs to market them. They are more often the disrupters of the status quo, and therefore should play a vital role within sustainability-oriented ISs.

However, in most cases, it is about society that accepts innovations and decides whether to adopt them or not. Hence the consumers for that business's products or services are vitally important. It is also consumers' SCIs that often determine the value and use of innovations in society. They are also sometimes the agents of production that are harmful to the environment or communities. In other instances, and most concerning, is that users can be fully aware of the negative effects of their own unsustainable actions and choices as individuals without changing. Their individual mind-sets or cognitive frameworks are embedded within SCIs that are shaped through old patterns of behaviour in society. Most often this is because no alternatives exists for them i.e. that a user could use. For example, if there is no infrastructure or provision for cycling in a town, it is difficult to start a culture of cycling. Similarly, if there are no alternative technologies to produce energy, not much can be done to transition.

What has been described above, however, is about how ISs can develop innovations as alternatives; and once they exist how they can be diffused and used in society. It is the latter purpose that has been the primary 'indirect' focus of sustainability transitions in the literature. Importantly, ISs possibly provide a more holistic approach to STs that includes a greater focus on the first aspect – of configuring the system to develop innovations that are sustainability-oriented in the first place. It is this argument that needs to be highlighted as the most important for STs. It provides the rationale for broadening the focus of STs to include socio-economic change processes through an IS approach. Innovation and economic functioning are certainly a precursor to any socio-technical change or transition. Without a solid understanding of ISs for STs as a theoretical approach for policy development, STs in practice will not be as effective.

Finally, the argument suggests that: i. It is easier for strong and functional ISs to develop innovations and diffuse them within society than it is for weaker ISs. ii. Despite their strength, this does not mean that they are sustainability-oriented or that they will produce innovations that provide alternatives to existing unsustainable systems.

It is for this reason, that an investigation into the subtle yet powerful influence of SCIs on ISs was proposed as a core distinguishing factor, and is the primary difference between conventional ISs and SoIS. The discussion on the role of SCIs in ISs, as discovered in the cases and generalized, now turns to the discussion about the findings in Theme II

8.3 Generalizations and discussion of findings of Theme II

The aims of investigative theme II were to find evidence for the assumption that ISs can become sustainability-oriented through the shifting of their SCIs, or through their adoption of sustainability thinking and knowledge. The answers to the research questions of theme II, suggest that SCIs as both informal and formal social constructs have a tremendous power to change the direction of ISs, and thereby also socio-economic systems towards sustainability.

Similarly, SCIs within ISs have an equal power to resist change, and continue on pathways of unsustainable development, driven by the perpetuation of unsustainable ISs. If innovation systems do not change, economies will not either. Socio-technical system transitions or system innovations are dependent on the directions economies and political systems take, and are driven by ISs. Regulations, finance and various incentives (e.g. tax) are mechanisms to change the direction of ISs, but ultimately from the perspective of the researcher, a change in the knowledge systems is required to bring about change in the direction of ISs. This is discussed more theoretically in context of the sub-propositions and RQs.

Sub-P2a: ***Socio-cognitive institutions are a primary enabling factor for determining the direction of innovation in RISs.***

Sub-P2b: ***Socio-cognitive institutions are a primary constraining factor for determining the direction of innovation in RISs.***

As discussed above, while the strength of an IS certainly assists in providing the ability, capabilities and capacities for sustainability transitions – its strengths do not determine the direction it takes. In fact its strengths may hamper it from changing course and allowing the development of innovations in new and appropriate directions. The findings show that ISs are

intimately connected to production systems, and sometimes are locked-into servicing industry in a particular way. The ability of ISs to influence production systems towards sustainability is ultimately important for an IS approach to STs. Direction here is related to path-dependencies, and socio-economic trajectories that ISs may shape or change. The discussion in the literature review showed that innovation can have both positive and negative effects on sustainable development. ISs, their elements, mechanisms and actors have likewise the capacity to shift production systems towards sustainability – but this depends upon the orientation of SCIs. Are they sustainability-oriented or not? On the surface, this question seems superfluous, and obvious. But through deeper investigation and gaining greater insights into how SCIs are shaped within and shape ISs, their importance for directing ISs for sustainability becomes apparent.

In this investigative theme, the primary aim and proposition was to provide some evidence that the phenomenon of SCIs plays a major role, but certainly not the only role, in shaping the directions ISs take. Subsequently the direction of ISs as discovered in the findings of the case study of the two RIS is heavily influenced by SCIs. These findings are discussed in the context of each of the case studies, the research sub-questions and as well as from the view of achieving STs. More specifically findings of the case studies are generalized to provide insights into: what is known about how SCIs develop within RIS, as formal and informal structures; how they may influence the direction of a RIS; and how they may thereby influence the socio-economic directions and socio-technical impacts of a region towards sustainability.

8.3.1 Knowledge systems and production are the most important drivers of SCI orientations

Socio-cognitive institutions, like institutions in general, create frameworks within which people and actors in the RIS understand, make decisions, and act. They are one special kind of institution that may develop both formally and informally. In modern day society, formal SCIs are represented by cultures, generalized perceptions in society, social understandings or ontologies. In turn these are developed over long periods of time, and reinforced by the 'knowledge systems' we create, including education systems of universities, colleges and schools. In discussing how SCIs develop, knowledge systems are probably the biggest driver. They also exert the biggest influence on socio-cognitive institutional development. However, SCIs include more than the knowledge produced and transferred from formal education

institutions – they include societal or transdisciplinary knowledge as equally relevant and important. From the researcher's perspective, TD knowledge includes the collective and deep cognitive frameworks and socio-cultural experiences within the knowledge institutions of society. This includes for example spiritual knowledge, belief systems and culture. At the same time it includes knowledge generated through formal research and education programmes.

TD knowledge is relevant for the discussion. Like formal SCIs, it is a combination of formal and informal knowledge systems. Formal SCIs are distinguished from informal SCIs by their degree of structuration in society and within ISs. Formal SCIs are characterized by a pervasiveness, rigidity and integration in society as ontologies or formal and deep knowledge structures. Within ISs the direction of formal SCIs is recognized in part by the direction of search of actors[58]; the research directions of universities, research institutes, competence centres and individual researchers. Informal SCIs, on the other hand, are easily changed. They range from attitudes, opinions, fads and trends to loose socio-structural arrangements. They may include elements of formal knowledge, but there would not be any research programme, theory or university department supporting their development. Formal SCIs are difficult and slow to change, whereas informal SCIs can both develop and dissipate quickly. The most important factor, however, is that SCIs are given their direction, to a large degree, by the knowledge systems they support, shape and develop, and which support, shape and develop them.

8.3.2 SCI shape their environments, and are shaped by their environments

Another important finding was that although SCIs always develop, and materialize within and through social network interactions, they can be influenced both internally and externally as social structures. The phenomenon of SCIs in society are generally different from those embedded within ISs structures. Outside of ISs, they are usually informal when they are social 'movements', yet their influence and power to shift formal SCIs within ISs cannot go unrecognized. This is a vital finding, in that it provides clues as to how individuals in societies can be influenced by the socio-cognitive institutions of which they are a part (or not, depending on the choice they make) – like fads, trends and social movements. Some commentators may refer to this as a 'collective consciousness'.

[58] This excludes 'deviants' and individuals as they don't form part of the formalized institution.

In the Austrian case, the collective consciousness, or informal SCIs on a macro level, was a powerful driver of SCIs that led to socio-economic change through ISs. It led to political change, as well as decisions that snowballed into a series of more formalized SCIs at the regional level of Styria. For example, the referendum leading to a ban on nuclear, and the hydro plant that was stopped from being built. These informal social movements, sparked events, which led to more formalized legislative changes almost overnight. This ushered in more formalized shifts in knowledge development for alternative sources of energy at universities. Interestingly, however, it was in fact the private sector that responded to these changes more rapidly, and approached the universities to co-develop innovations with them. Although a historical example, this shows how the strengths of close ties between the RIS elements led to a rapid response in building the capabilities, and thereafter the innovations to design, prototype and implement alternatives in society. These examples, however, show how SCIs can be shaped by their changing environments; but also shape external factors – like the change of legislation, and the direction of search and research once the legislation is in place.

8.3.3 Formal vs. informal SCIs, structures and institutionalization processes

The conversation about formal and informal SCIs can be related to the more theoretical discussions held in the literature review. Without going back too deeply into a theoretical discussion about the history of structuration theory, a few insights and parallels to SCI formation and structures are discussed.

It was not the aim of this dissertation to try to reinvent a theory of structures from a socio-cognitive institutional view. Rather it was to place emphasis on the socio-cognitive dimensions in the first instance; and place them more firmly within the context of 'structures' that exist in ISs; and understand how these SCI structures influence other structures such a normative and regulative ones as discussed in the theory. This is briefly elaborated on below. The key understanding of 'structures' from within ISs is to comprehend the SCIs as generalized relationships and connections between their elements and mechanisms.

Geels (2011), who provides the multi-level perspective framework, tries to overcome the assumptions of several theories that discuss structures, including evolutionary economics, science and technology studies, structuration theory and neo-institutional theory – each of which may contribute significantly to a better understanding of SCIs as structures (and would form an excellent topic for further study). Here, however, the departure point used by Geels (2011) and Grin *et al.* (2010) to distinguish between local levels and global levels as social

systems and social structures is useful for comparison to what is described in this dissertation as informal and formal structures of SCIs. The shift from local informal social systems to global formal structures would describe the institutionalization and formalization of SCIs. While institutions may form as the 'local' or micro level as described here, they are loose and are not formally represented in the ISs or RIS structures (i.e. they may not yet influence or be driven by formal knowledge systems like universities).

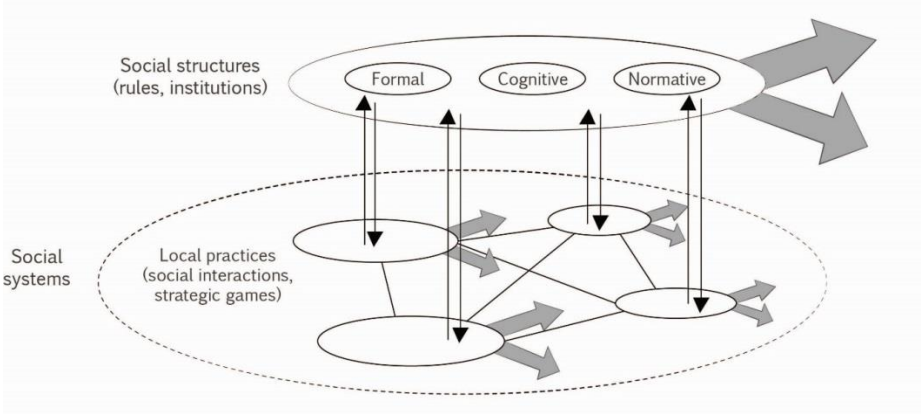

Figure 3.2 Social structures and social systems. Source: (Grin et al. 2010)

Figure 3.2 above, (inserted again for convenience) shows a distinction between these 'social systems' and 'social structures'. SCIs, similarly, would be akin to the 'formal structures' at the more aggregate level, and more informal social interactions, groups and loose-forming institutions at the 'social system level'.

Drawing on parallels to this theory is useful for explaining how SCIs, as formal structures, affect the direction of RISs. In the literature *formal*, *cognitive* and *normative* structures are discussed, whereas in the research cognitive structures are the primary focus. This does not mean to say that formal (regulative) and normative structures are not discussed at all. Rather, they are discussed from the perspective that cognitive influences may have on them. In fact the discussions explicitly include the influence SCIs have on other structures, be they social or institutional (i.e. social structures), or socio-technical, socio-economic or socio-spatial. It is strongly implied that these structures can all be influenced by SCIs, and be shaped and changed because of them. Again, SCIs are also influenced by these other structures. An example from the Austrian case that illustrates the influence of SCIs on socio-spatial structures is the concept that was proposed of a smart and sustainable precinct in the city of Graz. It was created and designed as an approach to urban sustainability. However, what is of

most relevance and interest to the research is the manner in which SCIs may influence the entire structure of ISs. In particular, the influences SCIs have on the set of institutions comprising the system of innovation. They may also be described as the ties, connections and relationships that exist among the elements, components and actors within ISs. A better understanding of how SCIs may influence the wider institutions of ISs is to see it as a key to unlocking the ability to transition to sustainability more rapidly.

What is also shared with the theory here, is the dynamics of local social practices (here social systems). Cognitive institutionalization happens when new cognitive rules become the norm. Formal SCIs would also influence and are in a way represented by both regulative structures which are a result of past SCI structures and societal thinking and normative institutions. As was suggested in the literature, normative codes are institutionalized when a wider array of actors, including authorities, endorse new codes of conduct, ethics, cultural values etc. Regulative institutionalization takes place when new laws or regulations are put in place (Geels & Schot 2010).

Finally, from the more theoretical discussion here, it is known that formal SCI structures are not easy to change. The rigidity and lock-in of deep SCIs structures are an explanation for why they may hamper the ability of RIS transitions towards a sustainability-orientation. As mentioned, ISs are often closely associated with production systems – which are socio-technical structures that can be even more locked-in. It is for this reason, that despite SCIs being proactive and oriented towards sustainability, they are not always able to shift the trajectories of both ISs and socio-economic structures. This discussion is related to the research question 2b, which is discussed in context of the findings below.

8.3.4 SCIs for sustainability influence innovation systems to become sustainable

ISs are normally embedded within, but also create SCIs in society. Societal knowledge or SCIs may be external to a RIS, like culture or social movements. Culture may influence the direction of thought within a RIS, and could be part of the embeddedness mechanism of RIS, as described in the literature. The other mechanisms in RIS, like financing and knowledge development could in principle be used to steer RIS. Embeddedness however, is an internal, structural and networked feature. Embedded ISs may both enable change internally or be shaped by external factors as already mentioned. In fact the other two mechanisms of finance and knowledge development within an RIS, strongly influence its direction, and eventually the qualities of SCIs as a part of the embeddedness. Wider knowledge bases, as socio-

cognitive institutional structures again influence and are influenced by ISs. These include production systems. In the Austrian case it was seen that there was a clear shift in the production systems, with sector innovation leading to the green and sustainability-oriented cluster of Eco-world. This was a result of slow, yet powerful formalization processes of SCIs for sustainability that began to infiltrate the system of innovation to become sustainability-oriented.

As suggested above, gaining a better understanding of how SCIs operate and influence the elements of RIS as formal and informal structures is very important. In this study insights were gained from the two cases, providing a substantial view on how this may take place. A detailed description of how SCIs for sustainability developed, often first informally then formally, was described in the findings. They were slowly institutionalized within the Styrian RIS, and as one respondent suggested, developed an institutional framework for green business development. The policy of clustering was also a powerful driver of building momentum in the green industries. The result was that these sustainability-oriented industries took up a large market share of the region. They also became the fastest growing industry in the region. This momentum also drove change in the wider SCIs that were not formally in 'support' of sustainability and signaled the start of socio-economic transitions in the region of Styria. The RIS became more and more sustainability-oriented and with it, solved several of the sustainability challenges within the region itself. This included the multiple socio-technical transitions to more sustainable systems which were derived from challenges perceived by Styrians. This included a range of transformations from the 1980s: dirty industry became clean industry, polluted rivers became unpolluted rivers, vehicle congestion and fine dust pollution was transformed by public transport, cycling lanes resulting in cleaner air. Other examples included sustainable energy systems (heating systems, PV systems, bio-diesel, wood-boilers and several others), general recycling, and recycling of glass. But the transitions also included a wide array of social change processes and social movements for better and healthier living which in the view of some of the respondents was as important as socio-technical changes.

It is within RISs that SCIs determine, for example, research directions, or direction of search that collectively as a system determines its direction. For example, political motivations, policies and formal research programmes also constitute part of formal SCIs and mechanisms within RIS. They frame knowledge and deep structural patterns of thinking within the ISs.

These more formal SCIs are guiding frameworks of reference for the actors, elements and mechanisms in (R)ISs. However, they also include the systemic and institutional character that connects elements as a collective whole. An SCI can be seen as a special kind of institution within an IS that ultimately determines its direction and innovation outputs. What is interesting about SCIs, whether they are formal or not, is that they can in fact change direction and shift rapidly, thereby also shifting directions of ISs. SCIs in both cases, were shown to develop, and change from old SCIs to new SCIs. The SCIs once changed, did not revert back to older SCIs: they progressed in new directions and with this also drove innovations in new directions. As discovered in the South African case, through the TTP project, it was not only new technologies that were developed but also new concepts, new strategies and new visions. SCIs and their changes are thus also a form of social and institutional innovation. They should be seen as equally important in the transition to sustainability within society.

From the findings in the Austrian case, more dramatic shifts in SCIs took place on numerous occasions, which altered the course of socio-economic development in Austria in a sustainability direction. Several of these examples were discussed in the findings. However, the most interesting were the two major events that took place: the nuclear power referendum, and the protest against a hydro-power station being built. Both these events represented the victory of powerful SCIs that had rapidly formed to compete against a dominant incumbent SCI. As was found in the inductive analysis, SCIs were and are strongly influenced through politics, media and public actions. This is a prime example where cognitive structures influenced both normative and regulative structures as described in the literature. However, this SCI change took place as a clash of SCIs at a macro level, and for this reason was quite dramatic in terms of a rapid change at a wider structural level.

However, it is understood from both cases, and from the findings, that SCI changes took place on a continuous basis all the time. They were being shaped and were shaping RISs as continuous contestation of different SCIs vying for power or dominance on meso and micro levels all the time. At the macro level SCIs are already dominant. However they can also change, as discussed above, because of events, shocks or pressures which can also quite quickly lead to more formalized structural change within ISs, such as new legislation in the Austrian case, or a new regional research program on sustainability. Another example could be the governmental decisions to support certain projects over and above other projects. All

of these factors combined, influenced by changing and competing SCIs may lead to more or less sustainable outcomes for regional economic development.

A further example of changed SCIs that shaped and influenced the RIS externally in Styria, was the new socio-economic dispensation after the socio-economic crisis of the 1980s in Austria. Before the change, rigid and locked-in SCIs went hand in hand with a rigid and locked-in state-owned industrial complex in Austria. Then the system changed and broke down through privatization. With this change, mind-sets were also forced to change, and with this came the formation of new SCI structures for sustainability in the RIS.

From the findings, it is clear that SCIs within RISs develop and are influenced both internally and externally. What is of greater interest for this study and for the recommendations for future studies is what internal and formal mechanisms can be employed to shift SCIs towards a sustainability-orientation. Again from the perspective of the researcher, the answer is knowledge development as a formal change mechanism. However, it could be other factors, too, like financing, regulations or policies supporting sustainability. In most circumstances these mechanisms aiding in the shift towards socio-economic transitions, would be derived and legitimized also via SCIs supporting a sustainability-orientation. This is true at least for a democratic society, where bylaws and regulations are collectively written, implemented or rejected. From the inductive analysis, it was clear that both politics and media played a major role in shaping SCIs at least informally. This brings the discussion to the next point, about how and at what levels SCIs may be influenced both as formal and informal structures. For example the media usually operates at the national scale, but may influence only small groups or micro scale SCI structures in society.

To summarize this discussion, the process of formalizing SCIs within an RIS, was found to be from informal to formal structures in most instances. Once formalized, these SCI structures became rigid, and were difficult to change and strongly influenced the direction of ISs and thereby the socio-economic directions too. In most instances, as discovered in the findings, it required dramatic events, or considerable pressures on the deeply engrained SCIs, for them to shift. In the Austrian example, the changes in socio-economic structures during the economic crises had a major effect on societal and ‘economic’ thinking as formal SCIs.

8.4 Generalizations and discussion of findings of theme III

The aims of this investigative theme were to better understand the differences and dynamics of SCIs, how they form, influence and grow at different structural and scale levels. The primary purpose of knowing this, is that it would provide insights into how to best devise interventions for STs, using an IS approach. The ISs approach has well established ideas about how to stimulate and govern innovation as a system for economic growth. Yet there is considerable room for a better understanding of how to govern ISs for sustainability. The view of the researcher is asserted throughout the dissertation, suggesting that ISs should be used as a tool to achieve STs on a wider socio-economic scale. Socio-technical systems are embedded within socio-economic systems.

As in the MLP, which is described in detail in the sustainability transitions literature, and briefly alluded to above, the notion that SCIs develop differently on different structural levels is shared here. What is missing from the literature is the link between these structures, and how they may be influenced and affected at different scale levels. The conversation of spatial and geographic approaches to STs has only just begun. Again the research asserts that the importance of geographic and spatial contexts cannot be denied, especially when considering how ISs function and how they are to be influenced/ governed. A more intricate 'understanding' of the contextual socio-spatial factors, like culture or regional identity, goes a long way in the debate on SCIs. For example, Italy is known for its 'brands' in quality fashion. This is not something that is tangible or transferrable, it is tacit and specific to Italy. In a similar way these socio-spatial contextual factors, were found to play a big part in shaping of both a Styrian identity, and a Stellenbosch/ Western Cape identity. Whereas the Styrian identity was far advanced in terms of a general SCI orientation towards sustainability, the Western Cape region was in a process of shaping its identity as a knowledge region. Regional innovation systems and local innovation systems are regarded as aggregate levels of ISs that are able to comprehend the subtleties of geographic space. This is needed in the theory of transitions, and especially in their contemporary management.

The regional innovation systems literature is appropriate to fuse together with ST literature and already deals with these socio-spatial subtleties. Both social and spatial configurations are extensively discussed, through the lens of proximities and associated concepts like: embeddedness, localized learning, local social interactions, local 'buzz' and global pipelines. These concepts, as discussed in the literature review, have a place within transitions theory,

where they would allow for better understanding of niche developments, and localized processes for sustainable development. These are also useful concepts for understanding how SCIs may develop within RISs at the more local scales, and also how they relate to more 'globalized' structural levels. A better understanding of how SCIs develop to support novel spatial nodes of development (like TTP and SID; or 22@Barcleona; or the Boston Innovation District) would go a long way towards enabling 'islands' of change that promote wider societal learning and SCI change in regions and nations. If socio-economic transitions are to be achieved the different spatial and structural differences need to be better understood. That is the research question for investigative theme III.

Sub-P3a: ***Socio-cognitive institutions develop and are shaped in different ways by various forms of proximities on different structural and scale levels.***

The relationship between social structures and spatial scales is complex. They, for example, produce the character of a place, and go hand in hand with people who live or work there. The spatial and the social cannot be reduced to socio-structural systems only if the theory of STs is to be better developed for transitions to take place. Transitions, both socio-economic and socio-technical, are heavily embedded within the socio-spatial fabric of towns, cities and regions. It was clear from the case studies that scale and structure do have an effect on one another. Proximities were a useful theoretical lens to unpack the various socio-spatial relationships between actors and elements in the RIS. In doing so, this study initiated investigations into these complex relationships from the viewpoint of integrating different social structures and scales. While these are already complex sets of socio-structural and socio-spatial relationships, they become more complicated when one tries to understand how influences of SCIs may interact dynamically within and between them. Examples of the case are provided below in Table 14 to reduce the 'abstract' view of what is being discussed here. It should also be noted here, that this 'finding' or conclusion of investigative theme III of the importance of combining structural levels to spatial scales to become socio-spatial is only just initiated through this study. Far more work on it needs to be done.

What is known, and discussed above, is that the environments that SCIs are in, in turn can shape this same environment – it is an iterative effect of influence and influencing. These 'environments' may exist as different spatial nodes, or districts in towns and cities of a region; or they may be more aggregate 'hypothetical' spaces where the rules of spatial proximity are more distant. The rules of spatial proximity, as discussed in the literature have

an effect on the other forms of proximity in their distance or closeness: for example, if organizations are close in terms of collaborative networks due to close spatial proximity. This relates to the internal and external dynamics of changing SCIs within and between the various elements and mechanisms of RIS. While it would be almost impossible to unpack every relationship and every influence between these structural and spatial scale levels, it is possible to make some generalizations about them from the findings. It is important to gain a better understanding of these complexities of SCI formation at different scale and structural levels. It may provide the understanding required to develop unique interventions to shift SCIs within ISs at different scale and structural levels.

For example, when the researcher was involved in the W.C. development of a RIS strategy, it was concluded that innovation system governance requires a multi-level and scalar view. There was a need to incentivize and promote innovation across the board, and particularly at a more macro regional socio-economic level. This could be achieved through various policies, legislative functions and/or financial mechanisms: a more aggregate support level for innovation systems that do not require spatial proximity. Sectoral and emerging clusters in the region would require support of a different kind, but again this is more about organizational, cognitive and institutional proximities that count the most. No doubt, a reasonable degree of closeness spatially helps to foster better firm-firm relationships, as was the case in the Austrian Eco-world. Although the firms in Styria were not on-top of each other, they were close enough to easily collaborate and cooperate. The reverse was true for the South African case, where firms were in extremely close spatial proximity, yet there was very little organizational or social closeness or proximity. The primary reason for lack of interaction being a spatial design or infrastructural one, as Technopark had very few spaces for social engagement. This was the opposite in the small towns of Styria, which had strong bonds of social proximities at the local scale. Many of the more radical innovations that were created in the Styrian region and later formalized into the Styrian RIS began at these local socio-spatial levels.

Why the socio-spatial becomes important, is for similar reasons to why concepts like strategic niche management have been developed. In SNM theory, it is known that looser structures at the niche level often provide alternatives to the ‘regime’ and thus should be supported. In a similar way, niches could be seen as socio-spatial and develop infrastructurally as different spatial nodes, or as projects, like the smart cities precinct in Graz. There is no denying,

however, that niches, as 'emerging' technologies, also exist as fragmented inputs across different geographies, but where transitions occur, they may be implemented geographically. Socio-spatial niches at grassroots levels, often supporting new technologies or a new vision (as in the TTP case) were found to be driven by alternative SCIs to the mainstream when pursuing sustainability goals. Although this may not always be the case, as resistance to novelty at the grassroots level may be 'at it strongest' for various reasons. However, what was found, for example, in the South African case was that once SCIs came closer together as close social and cognitive proximities, then change occurred. Spatial proximities certainly assist in this, but other factors like leadership and organizational support and a political will are equally important. As was found in the South African case, however, while the very different SCIs of actors in the LIS created conflict – it was overcome by finding commonalities and shared threats, and through visions for achieving sustainability. SCIs should thus also be added to the list of proximities, when gaining an understanding of the overlap of perspectives and knowledge communities between different societal groups. This includes triple-helix actors, who often struggle to overlap in their thinking and perspectives or understandings – at least in the South African case. SCIs, may develop, shape and be shaped differently at different structural and spatial scale levels. Knowing how an intervention may shift SCIs to sustainability informally, and more formally within an IS structure, could make all the difference for STs. While not all of the findings of the case can be discussed on all levels, a table is used below to describe a number of scenarios in which the spatial and socio-structural are brought together. Knowing how SCIs may develop within RIS, and how this can be generalized may provide clues as to how to more effectively manage and govern socio-economic transitions from an ISs perspective.

Table 14 - General examples of socio-spatial structurations within ISs

SCIs qualities and formation within RIS from a proximities perspective	
Local scale – *micro structures*	This was the most important level for developing SCIs for sustainability. Numerous examples from the Austrian case showed how SCIs, for sustainability happened through the close social and spatial interactions between RIS actors. Innovations taking place at this level and scale were however, often loose and informal networks that slowly began to formalize. In the South African case, of TTP, the close social and spatial interactions led to a vision for innovation and sustainability. Despite social conflict and institutional differences, new SCIs were formed collectively.

Local scale – *meso structures*	The local scales provided the seedbeds for new SCIs that supported sustainable development. In many Austrian case examples, individuals influenced, built and slowly formalized new institutions for sustainability. This took place at the local scale, but as their SCIs began to be legitimized within the RIS, it grew more formalized. This was the critical stage at which SCIs, usually following some form of invention, innovation or business, integrated into the more formal structures of the RIS at the meso level. In the South African case, there were strong localized SCIs for sustainability, and social development. However, they often remained at the micro structural level, due to the level of conflict. Coherent SCIs for sustainability battled to reach from local scale to meso structures due to the institutional weaknesses in the system. Trust was a major factor impeding the formalization of novel SCIs in the South African case. Intermediaries in both cases played a fundamental role in bringing new SCIs to the meso structural level, through boundary spanning and extension of SCIs in the RIS. For example through transfer of knowledge for sustainability, such as the activities of Green Cape from the meso-level to micro-scale.
Local scale – *Macro structures*	One example used in the Austrian case to describe this phenomenon of macro structures playing out at local scales are the daily 'farmer's markets'. These are deep structural, and socio-cultural habits derived from formal SCIs pervasive at the national level. Informal SCI, supporting solar home technology in the 1970s in Austria was an example of macro-structures that took place in spatially-based communities in Austria. In South Africa, a good example would be the science park policy, and efforts of the COFISA programmes, that influenced the researcher to design an intervention to 'transform technopark'. This was a national level SCI that influenced a local scale project.
Regional – micro structures	On a more informal level, this would refer to the social relations, and shared networks and perspective of regional actors in the RIS. It is this informal integration of societal perspectives and SCIs that holds promise for innovation. This is where notions like local buzz, and regional integration are important concepts and actions fostering novelty within a region. The success of the informal SCIs becoming formal is heavily dependent on regional social factors like trust and shared cognitive frameworks. In Austria the latter is a major strength, in the South African case it is its weakness. Formally the regional-micro structure scenario would constitute the emerging patterns of new knowledge generation, or new research, innovations that are driven by SCIs. These SCI structures may be part of the IS or RIS, but are not yet formalized. This is a very important dynamic for regional change, whereby the micro level SCI structures may be enabled or constrained depending on other prevalent SCI structures at the regional level. In both cases, novel ideas and knowledge developed at the micro level, but took some time before it was adopted more strategically within the RIS.
Regional – *meso structures*	Meso stuctures would be the established formal SCIs that form part of a RIS. There may be more than one, and it is here that the power and dominance of one SCI may exceed another. This is an important level, as it represents the RIS, and the SCI dynamics within it. At this level, SCIs are being created and shaped, and are developing internally within the RIS, but are

	also influenced by external factors like events, or trends on a more macro level. It is at this level, that SCIs, within RISs, are closest to production systems. SCIs at this level may be locked-in, as dominant perspectives serving old industries that may be unsustainable as in the Austrian case. However, also in the Austrian case, some thirty years later, Eco-world represents the meso structural level of SCIs for sustainability in the region. It supports the production systems of the eco-world cluster as a sustainability-oriented (sectoral) innovation system.
Regional – *Macro structures*	More generally, the regional scale was often host to imposed macro level structural conditions; this would include the legal structures, policy structures, financial and administrative structures. However, macro structures can also exist as powerful SCIs that are spatially contained at the regional level. Here 'macro' means that the SCIs are completely dominant. This could be in the form of regional cultures and practices for example. In the Styrian case, and within its RIS (more recently) it could refer to the strong Styrian identity of being something of a knowledge centre in Austria. Similarly, in South Africa, the Western Cape is beginning to develop a similar identity as the knowledge region of South Africa.
National – *micro structures*	At the national scale, micro structures are similar to 'niches' of the MLP, which are not necessarily spatially bound. They may exist within a nation state as projects, or interest groups of a similar kind. The concept of a franchise is a good example of a micro structure that extends at a national level as an analogy. In terms of SCIs, this is very interesting, as social movements that incite rapid change in larger structures often are not spatially bound. In other words this is about information or knowledge that is free-flowing that affects the SCIs of smaller groups of actors across a nation. The various movements, such as environmental protests in Austria, are prime examples of this.
National – *meso structures*	The national scale, has many smaller regional units comprising it. In a similar fashion, without being spatially based, there exist meso-level structures that support innovations. Or they may be new knowledge and knowledge systems that form part of regional or national innovation systems, for example.
National – *macro*	The equivalent SCI is a national identity or national culture. This is a powerful institutional structure that is very difficult to change rapidly, but is not impossible to change. In Austria, the two major events of nuclear and hydro protests were examples of how SCIs shifted overnight to support the ban on nuclear power stations. This combination of national scale and macro structure represents deep cultures of learning, knowledge, and attitudes and perceptions. From an ISs perspective this is a deep SCI.
Dynamics between structures and scale levels	As in the multi-level perspective, the different structures represented as niche, regime and landscape are static concepts. It is the interaction between innovations and these structural levels that animates them, and gives the model its dynamism. In a similar way SCIs can be seen as both non-linear and dynamic. They may be stable, for example at the macro level, but that stability is constituted through time. Time is an important dimension in the STs literature,

and similarly within the context of ISs for STs. A better understanding of how SCIs, may be shaped at the various levels, so as to enhance rapid changes in the ISs, may well speed up socio-economic transitions to sustainability.

8.4.1 SCI proximities within an RIS

The various comparisons between structures and scales described above can be further discussed in the context of proximities and their influence on how an RIS may influence STs. This allows for the inclusion of additional insights leading up to the integrated conclusion of the three investigative themes.

Socio-economic factors, which are not spatially fixed or are more aggregate, can and do influence socio-technical systems. They are a series of innovation and technology choices that are usually made by government, and implemented by the private sector – but most importantly they take economic factors into consideration. The socio-economics of STs cannot be discounted and should not be downplayed.

It has already been suggested in the GOST literature that there needs to be a stronger focus on 'where transitions take place' (Raven *et al.* 2012; Coenen & Truffer 2012). Below, the complexity of integrating socio-structural levels and socio-spatial scales is unpacked using a proximities lens in the context of the findings and an IS approach to STs. To begin with, however, the various possible combinations are discussed. This provides a basis for the final discussion about why the challenging endeavor of comparing structures with scales, in the formation of SCIs within ISs, is so important.

Knowledge development and its influence on SCIs, which in turn influence RISs is probably the most important finding of the research. In both case studies, knowledge development for sustainability took place informally at the grassroots level, and less so at wider aggregate levels. The reason for this was primarily due to informal spatial networks in close proximity. It was interesting to notice in the examples, how these various informal social cognitive institutions were developed at the grassroots level, and how they eventually became formalized and diffused within the structures, elements and mechanisms of an RIS. In both cases, when these SCIs were formalized, they became less spatially dependent, or bound, and extended to wider levels of engagement. From the literature this could be described as a process of tacit and 'sticky' knowledge becoming more codified (Asheim & Isaksen 2002).

However, this is not the same as 'analytic' vs. 'synthetic knowledge', as mentioned by (Coenen *et al.* 2004), which relates to epistemic communities in the sense of analytical knowledge, and synthetic in terms of a wider socio-cognitive community. This is because informal SCIs may be a combination of applied scientific knowledge and synthetic knowledge, but at a micro-level. In other words, informal SCIs may be transdisciplinary knowledge when it is informal and when it is formalized. Rather it is the uptake, and the spread of SCIs as knowledge within the ISs, coupled with social beliefs that formalize it.

To continue with the notion of extension of SCIs within RISs, it was also found that spatial proximities were important in their informal development – but less so in their formal development. Rather it was the other forms of proximity that became more important in their maintenance and further development in the RIS. For example institutional proximity played an important role in the coming together of different SCIs. In the TTP case, institution-building through the visioning process was an informal process that later became more formalized. At first it was spatially based, and required face-to-face meetings and events, and later was about the mobilization of institutions and organizations to support the vision, or develop it further. This is exactly what happened, as the TTP project extended within the LIS, of Stellenbosch to become the Stellenbosch Innovation District.

From the Austrian case, it was discovered that SCIs and their status within a RIS – as sustainability-oriented or not – played a major role in the direction it took. The wider environmental movement in Stryia represented certain SCIs in society that were competing with other and broader SCIs. These latter SCIs were not necessarily opposed to the new SCIs of 'environmentalism', but they remained rigid to them, and still do so in many cases. It is more a question of the inertia that is inherent in the deep cultural aspects of SCIs that are formalized institutions in society. For example university knowledge does not change overnight, it takes time to develop new curriculum, new directions for research, and to gain trust and funding etc. This is, however, a very important and key finding, as a better understanding of how to shift SCIs and individual mind-sets more rapidly in a sustainability direction would certainly aid the cause of STs.

8.5 Generalized answer to the primary research question of this dissertation (Main RQ)

Much has been discussed, above about the three investigative themes. At this point, without repeating what was said above, it is important to bring together the commentary, and the findings to provide a general answer to the primary research question:

How do SCIs within RISs constrain or enable pathways to socio-economic development for sustainability, in turn affecting socio-technical transitions to sustainability at different structural and scale levels?

As was discovered from the cases, the orientation and direction of socio-cognitive institutions develops in many different ways, and also differently in different contexts. There is also substantial evidence from both cases to support the notion that SCIs not only provide frameworks for decision-making within RIS, but also determine the directions of search and research. These latter two phenomena may direct entire innovation systems to focus on supporting specific directions for regional economic development. Conventional ISs are driven by SCIs that often do not consider the environment or people, and are purely driven by an economic profit or growth motive, whereas sustainability-oriented SCIs actively consider the environment and society. The difference in socio-cognitive frameworks at the micro level and individual level, are continuously changing, but it is their aggregate as institutions both informal and formal that impacts the direction of ISs, and thereby socio-economic activities and socio-technical transitions.

Final conclusions to the answers of the research sub-questions assist in answering the primary research question. It was clear that stronger and more functional RIS have a greater ability to transition to sustainability than weaker ones. However, it is not the strength of ISs that determines their direction, but rather the SCIs inherent in them. For a RIS or NIS for that matter to be sustainability-oriented it should be characterised by an overarching and systemic SCI supporting sustainability. While this may be unrealistic in the short-term on a national scale, sustainability-oriented ISs can be achieved at local and regional scales. At least in principle as guiding mechanisms, policies, financial incentives and spatial projects like innovation districts that drive change for sustainability.

8.6 Towards a model of sustainability-oriented innovation systems (SoIS) for socio-economic transitions to sustainability

The notion of sustainability-oriented innovation systems has been referred to on numerous occasions throughout the dissertation. Here a culmination of the thinking of this dissertation is presented and discussed alongside a theoretical model, represented graphically as Figure 6. The discussions above and within the findings are finalized and brought into focus using this graphic image and theoretical model of SoIS. It is embedded within both a socio-economic sphere which in turn is embedded within wider integrated societal, environmental and economic spheres. The latter represented as one global social-ecological-economic dimension of activities. The balance between the social, environmental and economic within this sphere represents an equilibrium state for sustainability. This is a hypothetical scenario, and should be the goal of SoIS which in turn is both dependent on and influences the socio-economic sphere of activities. It is within the socio-economic sphere of activities that socio-technical transitions take place, which arguably are heavily dependent on the SoIS as a driver of change in society – both social and technological.

One of the key notions in this dissertation was to distinguish between 'conventional ISs' and 'sustainability-oriented ISs'. To begin with it is proposed that SCIs for sustainability should be seen not only as a special kind of institution but also as a special kind of mechanism within SoISs. While the differences between conventional ISs and SoIS may be comprehensive the latter would certainly include sustainability-oriented SCIs as a part of the configurations of its elements. For example, within the knowledge and innovation infrastructures of a SoIS or Regional (SoRIS) there would at least be some research programmes or formal knowledge development directed towards solving sustainability issues. A SoIS's institutions would support financial mechanisms that are expressly sustainability-oriented such as green finance, sustainability education, administrative support for sustainability programmes and projects, and extensive research in both public and private sector for sustainability. Policies for sustainable innovation would be another strong and tangible factor that would distinguish it from conventional ISs. As an overarching rule, however, SCIs for sustainability become the most important distinguishing feature of SoIS. SCIs would cut across and infiltrate all elements and mechanisms of an IS to make it sustainability-oriented within SoISs. Two graphic models are used to describe each element and how SCIs are briefly discussed below.

The first model, shown below is a simple adaptation of the RIS model discussed in Part II of the dissertation. While that model, showed how the spheres or sub-systems of 'knowledge application' and 'knowledge generation & diffusion' are embedded within a socio-economic setting, here an additional sphere of 'the environment' encompasses all the socio-economic spheres and sub-spheres. The functional components of the RIS, and the NIS are embedded within environmental and societal domains. Actors, elements and mechanisms in this hypothetical scenario bring with them a novel SCI dimension to the entire functioning of the RIS and NIS systems. As an overarching shift and integrated perspective, SCIs that are sustainability-oriented should have fully permeated the entire system. The measure of it as sustainability-oriented is thus determined by its outputs and impacts on environment, society and economy as a system.

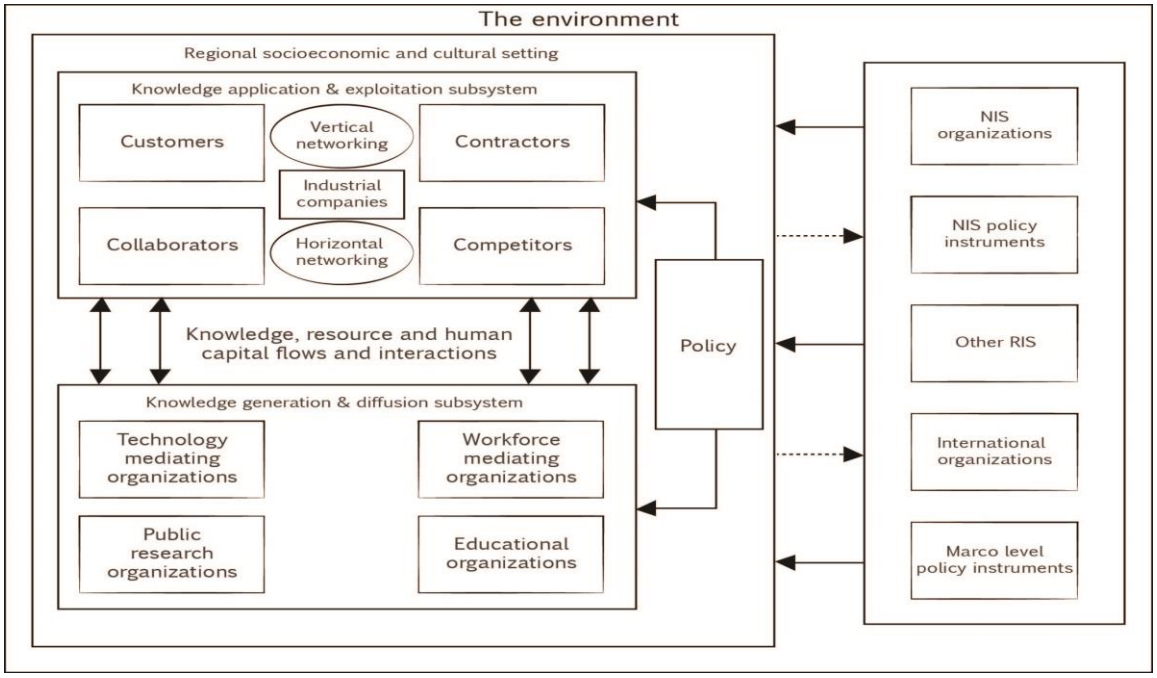

Figure 8.1. Sustainability-oriented regional innovation system (SoRIS) (Adapted from Todling & Trippl 2005)

The second diagram below, provides an alternative perspective from the view of the researcher and can be described in a similar way to the above. However it provides an 'extended view' as it includes a simplification of an innovation system, embedded within a socio-economic sphere (2), which in turn is nested within wider economic, sociological and ecological settings (3). The reason for this is to show that socio-technical systems (and resources) are related to and form part of the socio-economic sphere. They are kept separate,

because the socio-technical systems in a geography are highly dependent but integrated with socio-economic systems and institutions. Collectively they represent the economic sphere. They are labelled here as resources, because they also contribute as resources to the innovation system's functioning which is represented by the middle sphere 1. All these systems are shown by the arrows to be inter-dependent on each other, and one system can heavily influence the other. Finally sphere 1, which on its own would represent an innovation system, is nested here within the other two spheres making it sustainability-oriented. However, the core difference between this model and conventional models is the emphasis on the mode of knowledge generation as co-development between each of the innovation system elements and components. The core of a SoIS should be transdisciplinary. Transdisciplinary knowledge includes the disciplines which would be required as well, but it extends to include societal knowledge and SCIs of actors extending beyond economic and academic practice. It includes spiritual knowledge, and consciousness of environment and nature, and sustainability challenges.

The spheres marked 1, 2 and 3 are discussed briefly in dynamic relation to each other below.

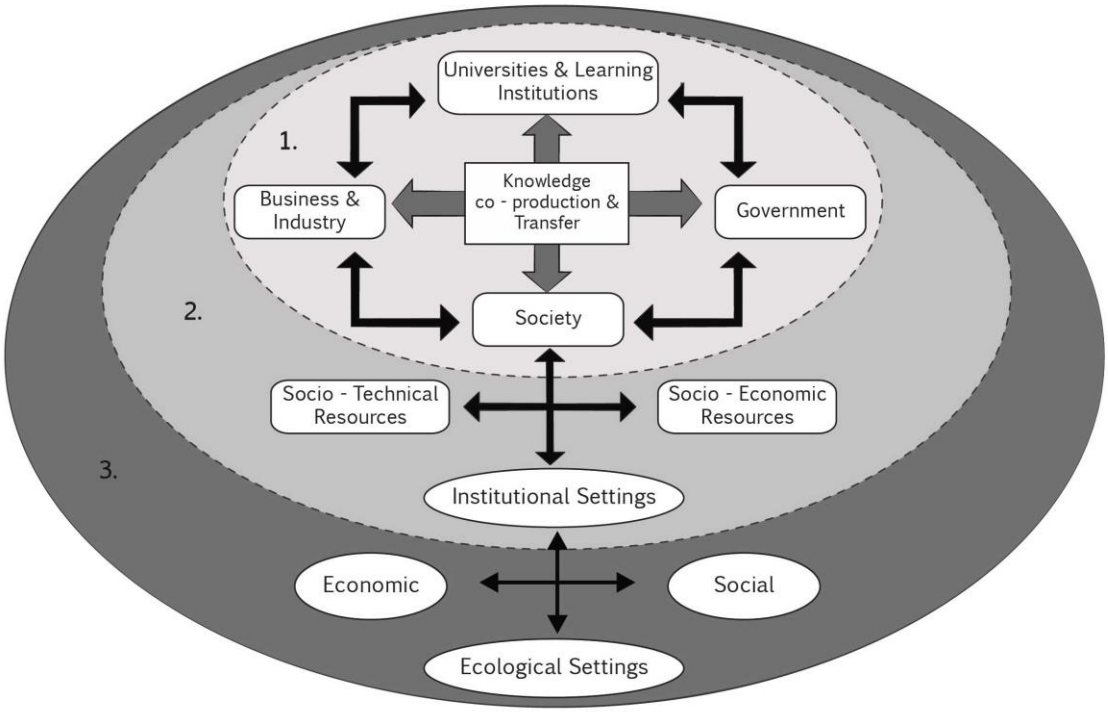

Figure 8.2. The sustainability-oriented innovation system as embedded within economy, society and environment (Author's own 2014).

8.7 The SoIS system, dependencies and influence on the socio-economy

Without sphere 3 as a hypothetical goal of a 'sustainability environment', spheres 1 and 2 would represent conventional socio-economic systems and innovation systems. Although 'conventional systems' already solve environmental or social challenges, they do not do so only, nor do they do so consciously.

In the SoIS, knowledge production is transdisciplinary and co-produced as a system between government, private sector (including entrepreneurs), universities and society (civil, NGOs etc.). As can be seen from the arrows, each institution (or organization) contributes to knowledge production and diffusion in the system of innovation. As in any conventional IS, there are also sets of relationships or connections between each of the components. For example, business with society, or business with the university, or universities with society and government. The nature of this relationship is usually based upon some form of exchange, whether it is knowledge exchange, or capabilities or expertise. If one of the components is weak, or doesn't contribute to the systemic functioning it weakens the entire system – as discussed in theme I. However, more importantly as discussed in theme II, is the SCIs that are developed both independently within the various components, and elements shown there. Each may influence the other's SCIs, whereby collectively the systemic SCIs represent sustainability-oriented SCIs. This refers to the internal ability of ISs to shift towards a sustainability orientation. It is dependent on the individual strengths of the components and elements, but also on the extent to which SCIs are sustainability-oriented. This determines if an IS is a SoIS or not.

However, the innovation system is dependent on the wider socio-economic system within which it is embedded. It is dependent on it for receiving resources to enable the proper functioning of the ISs. For example, if government do not want to provide resources for intermediaries that are sustainability-oriented it may hamper the system from becoming sustainability-oriented. In this sphere the socio-economic resources also refers to basic infrastructures such as roads, airports and transport – which affect the functioning of the IS. The more important influence, and of interest for the dissertation RQs was the dependency of the socio-economic system on the ISs, and the ISs ability to steer, guide and influence the socio-economic system in more sustainable directions.

Finally, both spheres, their functioning and operations, are heavily dependent on the wider 'sustainability environment' of social, ecological and economic. If they are dramatically out

of balance, there is the possibility of system breakdown. While this may be viewed as negative, it should also be seen as the opportunity for systemic change in a sustainability direction. It is ultimately however, the SCIs that drive the direction and functioning of the ISs that in turn enable both socio-economic and socio-technical transitions to sustainability.

8.8 General conclusion of the theory and recommendations

In the academic field of ISs research, the gap in understanding ISs as tools or policy guidance mechanisms for socio-economic and socio-technical transitions for sustainability is concerning. This dissertation aimed to narrow this gap by providing a specific academic view as to what distinguishes conventional innovation systems from sustainability-oriented ones. This has been achieved through the lens of socio-cognitive institutions.

The concept of SoIS, although not used for the first time in academia, is for the first time discussed here from a socio-cognitive perspective. The dissertation also provides a novel approach to its meaning, grounding this in two empirical case studies which have not been done before. Until now, the concept of SoIS, and what it actually is, or how it may function has been side-lined within ISs academic communities, and not fully adopted by the ST theorists.

SoIS, can be conceived of as a significant contribution to theory, which opens many new avenues for research and theory development in the context of sustainability transitions. Furthermore, and probably the largest contribution here, is the distinction between socio-economic transitions vs. socio-technical transitions. From the perspective of the author SoIS, is suited to both, and again opens up several pathways for academic enquiry into socio-economic transitions to sustainability.

The case studies provided insights for theory development in the fields of ISs and STs. Building on RIS theory through a better understanding of the role of socio-cognitive institutions in and between the elements and internal mechanisms of innovation systems provided a starting point. Developing a theory of sustainability-oriented innovation systems has begun here from a socio-cognitive perspective, and should be built on through other academic lenses.

The literature review aimed to provide a solid historical and theoretical understanding of the concepts of innovation and innovation systems, and their various delineations. This task was approached through a review of the classical authors in innovation studies and how their

thinking related to economic growth and development. Rogers' theory of diffusion goes beyond this. It is important not only for economic growth and change, but also for its valuable insights into ST theory: it emphasises both the pre-production and the diffusion aspects of innovation. This was a key finding of the study, and should become a greater emphasis in the work on ISs and STs. This is because, innovation as a process includes the spectrum from invention through to adoption and 'use' in society. It is difficult to imagine sustainability transitions taking place without adoption and diffusion of innovations in society. The IS approach takes this spectrum into account and will be useful in better understanding ISs as drivers of STs. It is undisputed in all the literature that was reviewed, that knowledge and its production and transfer are key factors in innovation processes. However, in understanding these processes, there has been a shift from a linear perspective to a complex systemic perspective. This takes the discussion to the kind of knowledge produced, and how this relates to society's needs. Mode-2 or transdisciplinary (TD) knowledge is most conducive to SoIS because it specifically seeks to solve complex or 'wicked' problems in society.

Innovation that stems from this mode of knowledge production is bound to be more sustainability-oriented because a greater emphasis is placed on: i. the steering of research priorities (i.e. towards a sustainability-orientation), ii. the commercialization of this research (i.e. clean-tech, sustainable alternatives) and iii. the accountability of science (to find solutions to global and regional sustainability challenges). If knowledge production is a critical factor for conventional innovation, then the TD approach to knowledge production is critical for sustainability-oriented innovation. It is a key recommendation that TD knowledge is promoted more aggressively for knowledge production within ISs across the board.

Here, the relation between the formal 'cognitive' aspects of SCIs and TD knowledge in the context of ISs becomes important in answering a deeper question about the kind of knowledge production paradigm required for altered SCIs. This is because TD knowledge and production methods include and recognise the 'informal' aspects of knowledge existing outside of technical disciplines – such as culture, norms, values and beliefs. Another important dimension that was discovered in the cases, was the time-dimension of actors and institutions represented by their SCIs. Long-term thinking led to more radical innovations, whereas short term thinking driven by economic profit goals resulted in incremental innovations. These modes of innovation, in relation to their influence by SCIs could be

investigated more deeply. The micro-level SCIs, internal to the firm would provide very good information on how business models are chosen. This would be a very important direction for research if linked to ISs and the work completed here on SCIs.

Another important reference to time is not only in the time-frame of actors and decision-maker within the RIS in the creation of innovations, but also in the diffusion of them. Rogers raised the time factor in trying to understand *the rate of adoption* of innovation in society. A parallel can be drawn between his work and ST theory, which also takes time into consideration in the shift from one socio-technical system to another. Time factors are important in ST, because the rapid development of unsustainable development trajectories requires urgent action. Rogers' categories of adoption may be useful for ST, because they promote a social perspective in the adoption of sustainability-oriented innovations that may aid transitions.

The review moved on from the classical perspectives on innovation to explaining the more recent national innovation systems approach. This thinking has been dominated by Lundvall and the Aalborg school. Their argument is that most of the institutions affecting innovation are developed at a national level (e.g. policy, laws, incentives, finance), and so learning should be understood in this national framework. The Aalborg school also emphasised that systems of production are different from systems of innovation. However, systems of innovation can be influenced by systems of production, resulting in lock-in, but also in SCIs locking-in as rigidities in the change of knowledge systems and directions of search. However, most importantly for this dissertation is that ISs can and also do strongly influence production systems. In fact they guide them, and the possibility for transitions of these production systems as socio-economic systems is made more acute with SoIS. Gaining better understandings and knowledge between production systems and innovation systems and their mutual influence upon one another within the contexts of transitions is another key recommendation for future research.

Finally, the RIS perspective had the advantage of stemming partly from regional science, which takes the geography and culture of place into account. It also has a more sophisticated view of the internal and external dynamics of ISs. Concepts like localised (interactive) learning, local buzz and global pipelines, embeddedness and the various forms of proximity are useful to describe how institutions may be formed in regional contexts. Insights gained from RIS theory certainly allowed for a richer perspective in the analysis of SCIs and how

they are shaped in the regional contexts of Styria and the Western Cape. However, the concept of NIS is not rejected: it is merely inadequate to deal with the socio-spatial considerations in this study. Further research should definitely be directed towards understanding SoIS at the NIS level more directly.

The most important common point from a review of the different IS literatures is that institutions and SCI are not uniform across a nation or even beyond national boundaries. Institutions exist at multiple levels in multiple forms, and are shaped through interactions from the global to the local scalar level. Both regions and national structures suffer from 'inertia': a reluctance of institutions, including socio-cognitive institutions to change from old 'codes' to new ones. However, regional institutional change can happen more rapidly than national institutional change, especially in the informal sense. National perspectives and cultures of thinking as SCIs may be seen as elements of a wider structure that takes time to change. On a local or regional level, proximities increase the possibilities for interactive learning and so influence SCI change. These learning dynamics vary across multiple locales and regional contexts in and between nations, and cannot be satisfactorily conceptualised at the national level only. Hence the need for a multi-level (macro-meso-micro) and multi-scalar (international-national-regional and local) perspective on institutional dynamics for innovation. The various combinations of these socio-spatial perspectives has the ability to provide insights into the multi-level governance of SoIS. The importance of spatial projects, or nodes of changed urban spaces, as showcases and 'islands of change' should not go unrecognised in its potential influence on the SCIs of regional actors. These in turn may provide powerful beacons of learning for sustainability, pioneering and influencing new SCIs for sustainability, that are adopted at more aggregate social structures and spatial scales. This view of STs was quite strongly focused on here through the lens of proximities. However, the influence of SCIs, from a more micro level perspective required further research. This forms another key recommendation for both future research, policy and practice – that of a spatial approach to sustainability transitions while integrating RIS and NIS as systemic drivers of spatial innovation.

Taking this more nuanced approach is key to gaining improved insights into differences between scalar regions, but also between different development contexts in the world. ISs in developing countries are quite different from those in developed nations, as discovered in the findings of the cases, and through the experience of the researcher.

Important insights have been gained through this research and in doing the study, which have been highlighted generally above. General recommendations for future research and policies have been given in Part IV. However, to conclude, specific policy and future research recommendations are given below as a summary. Final comments and conclusions are then are discussed briefly in the following section as the final points of the dissertation.

8.8.1 Specific policy recommendations

The dissertation has dealt with the considerable challenge of shifting socio-economic trajectories and pathways towards a sustainability-orientation. To achieve this it requires a more aggressive approach to integrating ISs, and more specifically SoIS into sustainability transitions policy and practice.

Based on the findings of this dissertation, and from the reporting of the three investigative themes the following policy recommendations are listed:

a) SoIS should become a mainstream policy tool and approach to socio-economic development and sustainability transitions. Furthermore, policies to foster more inclusive and sustainability-oriented ISs should be emphasized, articulated and strategized taking into consideration spatial and geographic contexts. Smart and regional specialization, represents a policy framework that could be built upon globally, while integrating a stronger sustainability transitions focus in it.
b) Greater emphasis on the governance of SoISs at different structural and systemic aggregate levels, including international, national, regional and local should be emphasized in an integrated policy approach.
c) Greater emphasis needs to be placed on contextual differences between different geographies within countries and between countries. i.e. between developing and developed nations with regards to the abilities and capabilities required to achieve sustainability transitions.
d) Very importantly, transition management policies (like in the Netherlands) need to take into consideration spatial dimensions, as well as SCI drivers of change through a SoIS approach. There is a need for transition policies for developing world contexts like South Africa, again associated with appropriate SoIS governance structures. These governance structures and SoIS should also take note of mechanisms for social inclusion. Thus SCIs within SoIS by definition should also be socially inclusive and environmentally conscious.

e) Appropriate policies need to be fashioned, to better understand the systemic role of knowledge production to foster formal (and informal) SCIs for sustainability to drive SoIS. A serious look at how knowledge is produced between business and universities, and how it is supported and incentivized by government is an essential priority. Transdisciplinary knowledge, and approaches should be more aggressively promoted by departments of Science, Technology and Innovation globally. Science parks, technology parks, innovation districts and other spatially-based innovation infrastructures need to be incentivized to become drivers of innovation for sustainability.

f) In developing countries like South Africa, there is an urgent need to look at policies, for not only strengthening institutions within ISs, but also for shifting them towards a sustainability-orientation. The latter is also true for all functional ISs in the developed world. Linked to this, mechanisms and monitoring and evaluation systems should be put in place to better determine both weaknesses and the direction of ISs. For example changing the measurements in national innovation surveys to include sustainability indicators.

g) In both developing and developed economies, a greater emphasis should be placed on entrepreneurial support for sustainability. Entrepreneurs, have the ability to act outside incumbent systems, and should be rewarded for solving social and environmental challenges more readily. Larger companies should find ways in which to support entrepreneurs externally, and where appropriate adopt or replicate their solutions, and business models. This approach may enhance capabilities for socio-economic transitions. To enable the strengthening of entrepreneurial capabilities, also greater emphasis needs to be placed on university-small business research collaboration, knowledge exchange and support.

h) In South Africa, trust building needs to be emphasized between different communities, as well as within the ISs and between actors. To do so a greater focus needs to be placed on innovation infrastructures in different socio-spatial contexts, with an emphasis on learning between them. Thus SoIS policies should explicitly include infrastructural and socio-spatial dimensions in building capacity for sustainability transitions.

i) To enhance the shift of conventional ISs functioning towards SoIS, both conventional policy mechanisms like tax incentives should be coupled with novel approaches as mentioned above. In addition, a strong challenge-driven approach to innovation should be fostered through governmental support and agencies as a key strategy within SoIS.

Within this approach, there should be a recognition of new knowledge production, that may lead to commercialization and diffusion of innovation in society. Financial incentives and regulations will play an important role in driving this shift.

j) In general there needs to be a greater emphasis on developing policies that comprehend the socio-economic drivers for sustainability transitions. This includes regulatory conditions and incentives for shifts in industry, M1 and M2 type of clusters, as well as SMME's. Greater support for cluster and sectoral innovation system intermediary agencies should be provided for, especially in developing countries.

k) There needs to be specific policy that allows for certain towns or cities to become experimentation spaces by reducing regulations and red tape. Similarly, municipalities need to improve their role as enablers of socio-economic transitions. SoIS can be supported at the local level, as sustainability-oriented LIS, through changing patterns of municipal procurement policies to foster new innovations. Special national government budgets allocated for reducing risks of experimentation should be considered. Special legislation and policies to support sustainability-oriented smart city precincts and innovation districts should be considered as infrastructural drivers of innovation and collaboration. This is also urgently needed in South Africa, as policies of separate development in the past hamper socio-cultural and socio-spatial integration. This in turn has an effect on the development of new SCIs that are socially progressive and sustainability-oriented.

8.8.2 Specific recommendations for future research

While some of the above policy recommendations can be understood and implemented directly, in other instances additional research is required. While this dissertation sets the tone for a foundational critique of conventional ISs, to achieve this far more research needs to be conducted. This should include more research to foster new theory around SoIS approaches to STs as well as focused and in-depth research on related but focused or isolated topics. Finally more empirical case studies of a similar nature as conducted in this dissertation should be promoted. Below a summary of recommended future research, to advance both theory of SoIS for STs and for advancing the policy recommendations above is listed as a summary.

a) Research is required in better understanding the differences between conventional ISs and SoIS, not only from SCI perspective, but from other fields of study. Deeper socio-

economic and business perspectives should also be advanced, so as to promote STs as more than socio-technical transitions. The economic drives of STs need to be better understood and require more research. STs should make economic sense, and should not be left to ethical principles alone.

b) Future research is recommended and required to measure SoIS, not only economic measures but especially in terms of social and environmental positive impact.

c) More case study research is required, on gaining deeper insights on STs from an ISs and a geographical point of view. The notion of SCIs within spatial conditions also requires far more research to begin understanding the valuation of intangible factors contributing to the knowledge economy and sustainability.

d) As is stated numerous times in the dissertation, the diffusion of innovation within geographical locations is what underpins sustainability transitions. More work is needed in the SoIS and ISs frameworks to understand the link between STs and diffusion and adoption of innovation in society.

e) Greater emphasis needs to be placed on social learning around sustainable technologies, especially in the developing world context. It may hold the key to more rapid adoption of sustainability solutions.

f) A vital piece of research that is required, is in better comprehending, how knowledge exchange and TD knowledge systems may function within SoIS. As well as finding ways in which to track impact of knowledge systems on the innovations that are produced as a result.

g) In South Africa, research is required on trust in society, utilizing the proximities model. This will shed light on issues with cohesion of SCIs, and also better inform policies to promote knowledge exchange and institutions building for STs. Utilizing this same model work on socially inclusive innovation systems can be done.

h) More in-depth understandings on the role of conventional governance mechanisms for ISs and new governance mechanisms should be investigated. Specifically around the role of multi-level structures and how they are linked to different spatial scales. This was the focus of investigative theme 3, which requires more focused and in-depth case studies.

i) Very importantly a great deal more research is needed on understanding the role of knowledge systems within SoIS. Specifically the role of knowledge creation in the formalization of SCIs that are sustainability-oriented. In addition more research may be conducted from an ISs perspective on how we view SCIs as tangible assets in the

knowledge economy, and in society. Furthermore, there should be greater recognition of the role of formal and informal knowledge structures – especially in developing world contexts – and where TD research approach can be applied.

j) Important research should be conducted on how to shift SCIs to sustainability, through knowledge systems, but also through developing collaboration and learning spaces. Targeted policies to promote exchange of knowledge between different SCI communities should also be investigated.

k) As this dissertation has demonstrated, it is recommended that future research is conducted on the socio-economic drivers of STs, and not only on socio-technical change.

l) Spatial and geographic contexts and conditions of ISs and STs should be further investigated. This should also take into consideration the differences in structural levels and spatial scales as has been investigated in this dissertation. The reasons are that both socio-economic and socio-technical transitions are firmly embedded within socio-spatial infrastructures and the fabric of towns, cities and regions.

m) More work is needed on how SCIs form at different spatial scales and structural levels. Within this context, STs theorists and practitioners can learn more about the subtleties of spatial dimensions and proximities to enhance its depth and effectiveness.

Finally, this dissertation has paved the way for considerable future work in fusing ISs theory with that of STs theory. However, it also provides the foundation to develop a theory of SoIS, which becomes a much more powerful driver of not only socio-technical transitions but socio-economic transitions. Below the final comments and statements regarding the findings are concluded.

8.9 Final comments and conclusions

1. It is the re-configuration of ISs and their governance mechanisms that will lead to rapid sustainability transitions. Figuring out exactly what those configurations are, and how they could assist in the governance of ISs towards more sustainable directions, may be the most urgent challenge of modern economic theory, policy and practice.
2. It is the speed of transitions to new social, technological and economic systems that is of importance in achieving sustainability. SCIs may provide the clues as to how to shift ISs more rapidly towards a sustainability-orientation, but this needs to be understood within different contexts and different socio-spatial levels.

3. ISs are powerful because they create knowledge, use knowledge to develop innovations in society, and are ultimately shaped by knowledge systems. The direction of knowledge systems is also ultimately determined by existing locked-in SCIs and new SCIs that are created and developed by the environments which they operate in. The ability of ISs to impact on sustainability does depend on their strength, but more so on the SCIs that determine their direction to create solutions for sustainability. Weaker ISs hamper the ability for regions, and by extension nations, to transition to sustainability, both socio-economically and socio-technically.
4. For ISs however, to shift internally to become more sustainability-oriented there is a need for a shift in SCIs, and with that informal and formal knowledge systems shifts to sustainability.
5. If ISs do not purposefully become sustainability-oriented, the goal of SD will be missed. STs will take too long and so avoid achieving the moving targets of sustainable development.
6. The difference between conventional ISs and sustainability-oriented ISs, should therefore be more prominent. Conventional ISs and their negative impacts on the environment must ultimately be replaced by SoIS.
7. Knowledge development and its influence on SCIs which in turn influence RISs is probably the most important factor of influence on SCIs. Therefore a greater focus on what determines and promotes the direction of research should be a core interest of those trying to achieve sustainable development.
8. Activism, lobbying and leadership within ISs, need to be supported by intermediaries who are system builders and boundary spanners. They are able to strongly influence the directions of search of firms, policies by government and research by academics. Finance and policies to shift ISs in a sustainability direction should not be underestimated.

Ultimately, if sustainability transitions are to be achieved, then knowledge systems, which are a core element of SCIs need to be urgently and more intensively directed towards solving societal and ecological challenges. Knowledge generation for sustainability and the knowledge's availability for use and diffusion in society needs to be the driver for shifting innovation systems and socio-technical systems within the economy in a sustainability direction. Sustainability transitions ultimately lie in the collective SCI of a global society. It is the conscious development of SCIs for sustainability that is required if the new United Nations sustainable development goals are to be achieved.

9 Endnotes

[a] a) The science system – whilst strong in many developed countries, it is often weak or non-existent in developing countries. Most urban and competitive economic regions in developed countries have access to tertiary institutions and R&D facilities. This is often not the case in LDCs, or their science system is quite weak in comparison. It is for this reason that many LDCs prefer to focus on incremental innovations and technology adoption as opposed to trying to compete and produce fundamental or radical innovations which requires considerable research capacity. This is not to say that radical innovations have not occurred in developing countries, but they are not the norm.
b) Focus on innovation – The focus on innovation in LDCs is often different. Whereas in developed nations the focus is often on high-tech innovations such as ICT with an eye to high end consumers, this is not often the case in LDCs. They have different priorities for development and often the innovation that takes place is more about adopting and re-engineering existing technologies sourced from other countries.
c) Interactions and learning – In LDCs, the triple-helix ties between university, industry and government are often quite weak. This hampers the ability of developing countries to learn, and co-develop the strong knowledge and technology bases necessary for innovation. Often innovations occur far more readily in firms and networks and between firms and users, than in university-industry relations.
d) Institutions, heterogeneity and culture – The NIS concept was partly developed in the context of the smaller Nordic states, which are homogeneous and have strong traditions and cultures. They also have strong and thick institutions, that aid in supporting economic and innovation activities. The learning culture and capacity for learning is high, because the entire population is literate and has at least gone through basic education. This is not the case for most LDCs, as education levels and expertise are generally low and unevenly distributed. In LDCs, there are also thin or very weak institutions supporting economic activity. This problem is often compounded by a clash of ideologies or world views (i.e. a clash of institutions) arising from the heterogeneity of these societies. This can severely hamper development progress because it issues in a reluctance to collaborate, making the innovation system inherently weak. See Lundvall et al. (2009), Metcalfe & Ramlogan (2008), Pietrobelli & Rabellotti (2011), Srinivas & Sutz (2008) for more in-depth perspectives on the subject of developing countries and innovation systems.

[b] In linking these theoretical constructs to research theme III, a word of caution is required. The concepts of local and micro, meso and regional, and macro and national seem to be used interchangeably. Although there may be instances where these social and institutional structures overlap with geographical territories, it would be unwise to equate them with geographic scales in all instances. Rather the notion of different forms of proximity dynamics in relation to the micro-meso-macro framework as proposed above would be more appropriate and also accurate as an analytical framework to assess innovation systems. This could be true for both 'conceptual' and 'operational' innovation systems.

[c] Eco-world was marketed as the No.1. clean-tech cluster globally, which was a clear indication of the SCI that supports it. In affirming this with Firm X (2012) the following response was given:

Ja, and I'm willing to believe it, I think that they are really up front there with established companies as well, so there might be areas where there is more research done definitely or there is more money going to the research but I think that established companies like BDI, like Komptech, like other players who are successful now for decades in this business, we are quite unique I think and that's one of the things which I think is an advantage of Eco-world Styria, not only to have a group of companies in this field, to have a group of experienced and long-term experienced companies in this field.

[d] Firm W's (2012) internal restructuring and shift in their business model was a good example of this. First of all, its decision to find a solution to glass recycling was due to external societal pressures to reduce energy consumption, and stop mining for sand for the glass industry. Firm W, decided to shift one of its core operations and with it a new business model to assist in the recycling of glass in the region. These external pressure factors, but also the knowledge that the university was in a position to assist the company with research to make the change had a direction impact on the decision-making of a few

leaders in the firm. The knowledge of availability of resources to make the shift, aided not only their decision, it further institutionalized the socio-cognitive paradigms of actors in the whole industry towards glass recycling. This included the firm's employees, the firm's suppliers and eventually the users in society. Users had to change their SCIs as well, because they now had to begin recycling glass, which was reinforced by legislation and the necessary infrastructures in the communities to do so. A similar case of socio-technical transitions took place in the waste recycling industry that stemmed from new SCIs to support these transitions in the RIS. This was a case where SCIs eventually became wider and more generalized institutions of recycling. This was not an innovation anymore, the socio-technical systems for recycling became institutionalized in society.

[e] The example of the PCCL, doing research for special long-lasting polymers for solar PV is an example of knowledge production for sustainable innovations. This research is conducted in partnership with industry. Govt & Int G (2012) and Govt & Int J (2012), however, also pointed out the danger of knowledge production that is too closely influenced by the private sector. This may influence the direction of research into short-term solutions, with a greater focus on incremental innovations. From the ST's research and literature this is known to be a problem for achieving sustainability in a situation which requires radical and systems innovations. In the Styrian RIS, however, there was substantial R&D taking place in the private sector, and the other clusters. These capabilities slowly began also to become influenced by the topics of sustainability. But the larger clusters like the car industry would fund research on incremental innovation to improve efficiencies of fuel combustion engines (Academic K 2012). One academic from Karl-Franzens University, explained how this university in the RIS may have influenced a sustainability direction in society:

The answer would be yes, sure the university has influence on it but I think it's more complex in terms of being a two way influence. If you take for example our environmental systems studies, that was not pushed by the University of Graz as an institution, it was pushed by the students, I would say students are more or less society, they come from society, they came to the University of Graz and they said we want to study environmental system science, they set out their own curricula, the University of Graz for example was the enabler, we supported that and we had some scholars and some colleagues here who really, we help you, we support you and then they made some class curricula and they supported the students, this was quite complex the student to apply to study that in the ministry in Vienna, so this was quite complex. So there was a response, you know there was ... but I would say also this was a grassroots movement coming from students or coming from society and the university was then enabling, reinforcing and now we have 1500, a little bit less than 1500 students involved in environmental systems science.

(Academic L 2012)

Whilst the trend of 'sustainability science' in terms of teaching had begun, in KFU, there was research to improve efficiencies in systems engineering for example at the technical university (Academic P 2012). The technical university however, had traditionally produced knowledge that was closer to industry and more useful to it. The traditional, 'ivory tower' research production was also challenged at KFU, as suggested by one of their Vice-rectors:

We cannot do science for science's sake because we have 30 000 students who will go outside and we will do something in our society and it's very important task for us to teach things like responsibility and also thinking outside their own perspectives, because our alumni are everywhere in our society

(Academic N 2012)

This trend was also the case for Johanneum research, which primarily targets issue-driven research for society and industry (Academic R 2012). There was thus a clear trend that in more recent times (since 1990's) research production was influenced by a shift in SCIs in the RIS. However, this shift also served to influence and formalise SCIs for sustainability. This perspective was reinforced by the response from firms in interviews with them. Most firms suggested that research in the Styrian RIS, had become far

more relevant and issue driven in the last two decades and included research for sustainability (Firm U, V, W 2012).

[f] According to the academic respondents, many of them believed there was still not enough funding of sustainability-oriented research in the RIS (Academic O, Q & R 2012). There was funding available not only from different levels of government, including national and federal state level, but also from private investors and venture capitalists. Academic R provides a good summary of this complex financing situation in the Styrian RIS:

Yes, that's a difficult question in that sense that you know, we're not really a federal state and we are kind of a multi government, a multilevel governance context, which means, Universities are mainly governed by our national government, the Ministry of Science is responsible for that and that is also social science for Scientific Research FWF. At the same time, you have a regional level, you have some money available, especially for applied research and fostering of industry-science cooperation, but to make things even more complicated, you have a more powerful instrument in that direction also on national level. You have those competent centre programmes, for example, that have been run since 1996. They are initiated by the national government and industry can apply for this, it's up to them and if they want to enter, they have to co-finance, which is of course, binding regional money which could be then not be used anymore for other purposes.

(Academic R 2012)

[g] Climate change was a more specific topic that was promoted by CCG, and was used to bring awareness and cognitive proximity to the concept:

We [CCG] made a study last year with marketing, because we want to know how do the Styrian people feel or they think about climate change, about energy efficiency, energy issues. Society are well informed, and we got the feedback Styrian society know many things about this topic – but the step from thinking to doing isn't implemented.

(Govt & Int E 2012)

[h] Later the knowledge and cognitive proximities expanded to include the farming community, and then wider society in general (Firm X 2012). A similar story was relevant for Firm Y (2012). It started out with a group of home inventors that tried to invent and install a solar heating system for their home. There was extremely close cognitive and social proximity between the inventors and a university associate professor in developing this technology in the beginning, simply because it was such a novel idea in the '80s in the region. Later the cognitive proximities grew, and the installation on the inventor's home became something of a showcase in society, attracting literally busloads of people to see the new technology and how it functioned. This 'showcase' eventually became an innovation on the market and today it is an international company. The point to be made here, is that several of these types of innovative technologies for sustainability began with small groups of entrepreneurs in close cognitive proximity. This meant their knowledge of the technology was shared and co-developed in specialized niches, quite isolated from other actors in the RIS. The cognitive connections and proximities to other actors in the RIS, (e.g. financiers and government) slowly grew as the knowledge of the technology or innovation diffused within the RIS and society through leadership in entrepreneurship (Firm S, Y, W & T 2012).

[i] Firm W (2012), described how their firm won a prestigious German award for being the best open-innovation firm in the 'Dach' region, which included Germany, Austria, Switzerland. Firm X (2012) provided the example of how they co-located with a partner firm to enhance competitiveness in both firms through sharing of resources and expertise. SCIs for sustainability in the RIS, and especially in firms spread rapidly through the practice of open-innovation and clustering.

[j] This town, in the 80's and 90's was far smaller than Graz, and a lot cheaper to live in. Many university professors and researchers lived there and worked in Graz. This group of people also had a strong inclination towards sustainability and were associated with the environmental movement. Gleisdorf was one of the first towns to strongly promote the concept of SD, and actively began developing and implementing sustainability solutions in the town itself. This was also strongly supported by the mayor of the town, who implemented showcase solar technologies (Govt & Int A, E 2012; Firm W 2012). This reinforced SCIs for sustainability in the spatial location of Gleisdorf, which began to specialize in solar technologies and hosted a small spatial cluster of innovative firms for sustainability. This was also true for several other small towns in the region that began to host companies that specialized in some innovative technologies for sustainability. Govt & Int E (2012) respondent summarizes this finding:

I think the university is very important in Styria and we have many innovation companies, especially not only in Graz but outside, I don't know if you know the town of Murek, Gleisdorf, and the energy renewable, Weitz, and they have a good small group who have a high interest to discuss [innovation and sustainability], to make new technical systems for energy, renewables, and we have small companies in Gleisdorf, all work together in the field of energy, energy production saving, efficiency, climate protection and so you have many informed people push the public.

[k] Another practical example of social proximities and the development of SCIs is described by Firm Y (2012) of their solar water heating system for homes:

It was not so much in the cities. Typically for new technologies this is often coming from the cities, from higher educated people. But actually this momentum came more from the rural areas and the background was that in rural areas everybody would have his own wood stove for heating the house and also the hot water was prepared with the wood fire and this had meant in summer time that you had to heat your oven every second day or so, depending how big the storage was and people did not want to care for heating the oven every day or every second or third day and that has been the biggest motivation in installing the solar thermal heating system that does this simply by itself without big effort, just in terms of longer periods of bad weather. During such periods well, you use the oven 10 times a year or something like that. It was not really an economic driver behind the need, it was just – I want to have this…

However, social proximities and their closeness on a broader scale was also actively promoted by government and intermediary organizations like Eco & Co, Eco-world, SFG and the local government (Academic L 2012). This was done through events on specific topics of interest for sustainability in the region (Academic P 2012).

Several other examples of the importance of social proximity existed, including the importance of meeting space and places in towns and cities. Academic N (2012) gave the example of fresh produce markets, which were a long tradition in Austria. They were places where ordinary citizens gathered and shared ideas and stories which she suggested had a big impact in shaping SCIs for sustainability. Another example was the development of a sustainable innovation in the rural area. That involved farmers and their social networks in the development of bio-diesel. The first bio-diesel plant was developed and operated in partnership with farmers, but also eventually expanded to include other actors in the RIS, including a politician and university professor (Firm X 2012).

[l] This had an effect on Austrian SCIs in general, as they were no longer perceived as leaders since the responsibility was now above their 'heads' sitting with EU legislators (Academic Q 2012). This was also suggested by Academic K (2012), who had been a politician before entering academic life:

I would say that economic growth and the position of Austrian changes we went through concerning our position in Europe as well were most influential on the society as a whole because the international dimension became more important and had certain links to the concept of sustainability as well.

Firm U (2012) also provided their perspective on the entry to EU as a big change:

I think the largest change for Austria in Styria is beginning of European Union and for Austria especially the year I think, 2001 to change the money from Osteriches shilling to Euro, it was a big change for us. So we are, we think European, not only we are Austrian or we are Styrian, I think this is opening the minds from the people and there are much discussions from European Union – not to go or go.

[m] Another view by Govt & Int Q (2012) of the required vision to achieve sustainability in the region of Styria is captured in this excerpt:

We have to have progress on three fronts. The one front is of course an ecological front. Graz is quite far in many ways, but not there, that in particular means a change in the energy efficiency of the city, less so in a material efficiency because we are far along in material efficiency per se. Second thing it means a change in the social fibre in terms of a much higher inclusion in power so in Graz it's not very common. And the third front would be progress on cooperation so interlinking different sectors of society but also different businesses, sectors would be important for us to become sustainable, so a lot of things.

Interestingly here too, a social view is provided in terms of the interlinking and connection within the RIS, and a change towards greater 'inclusiveness' in power structures.

[n] Austria started to build up a little bit of a national [sustainability] identity. And this became on the one hand an opportunity for industry, on the other hand a threat – why? Austria from those days on always tried to have a golden plating or set the standard in regulation. When Europe said, hey, Austria made A+ this is not always positive for us, not always good for industry, but on the other hand you're facing a constant pressure to develop new things and to adapt to those regulations and sometimes you invest in better technology and you think earlier about efficiency and you are forced to deal with products which are better off with these regulations and you're just 2 or 3 years ahead sometimes. At the first you're not very happy with that because you have shrinking competitiveness, economical or monetary competitiveness when you compare yourself to your international competitors. When 3 or 5 years went on you're realizing that brought you a sort of advantage. And after that you stick to that advantage and try to push it forward. Well, let's say the development in Europe and I think the worldwide development now is in favour of those companies who early tried to invent processes and profit in those fields. But talking about green technology, one has to say that green technology is not something entirely new, growing out of a new garden. (Govt & Int H 2012).

[o] Examples of the various social movements at the grassroots level are explained by Academic O (2012):

We had in the 80s at least very strong bottom up activities so the foundation of the green party in the middle of the 80s, all kinds of NGOs and local groups fighting against any project influencing the environment in a negative way, any new highway or new factory or new power plant etc. it was very active from this bottom up movements.

CCG, was a keen supporter of grassroots social movements for sustainability and behaviour change and assisted these in becoming more widespread (Govt & Int E).

[p] Similarly, the RIS itself was often influenced by small changes in wider SCIs that resulted in new directions for search and research within the RIS (Academic R 2012). The story of recycling also started as a not-in-my-backyard (NIMBY) SCI at the grassroots level protesting against burning of waste. This sparked a social movement that was immediately supported and taken up by the regional government. A learning programme for recycling was started in schools which rapidly changed the micro-level SCI structures to meso, and quite quickly also to macro level SCIs for recycling. Following this trend, came new infrastructures and socio-technical systems to support recycling (Govt & Int B 2012). There are several other stories of micro-level social movements for sustainability that received support from the regional and national government to strengthen and formalize the SCIs. These include bio-diesel, wood boilers, glass recycling and solar home systems (Firm V, W, X & Y 2012). Another rapid shift in the SCIs on all levels occurs in a crisis, which can rapidly change perspectives and attitudes on all levels simultaneously. Here is an example of how the oil crisis changed SCIs of RIS elements and agents to seek alternatives to oil:

to put it in a time frame so to say, we had the crisis '79, the university started to investigate throughout the 80s and in '91 we built the first bio system, which was a clear outcome of research. We were able to for the first time offer technology who was able at that time to use rape seed oil produced by the local farmers and to transfer it into a light fuel. And from that time on when it was seen that this idea from scientists can put into an industrial size farm, the whole business started to grow. (Firm X 2012).

[q] Another even smaller structure that emerged out of the SISN that was co-developed with the researcher, was a group of business persons who were interested in developing a website for Technopark. The primary aims were to aid in online communication with a wider group of stakeholders in the park, including profiling each of the resident firms. The intended use of the website as a tool for further debate, and engagement on the forums 'page' (www.technopark.co.za) did not work as well as expected for a number of reasons.

[r] More public spaces and spaces to meet people informally, parks that kind of thing, places to eat, swop-shops. Community garden after school facilities, that's what we see in 2015 and also involve the community with open days and maybe get people from Khayamandi [the local township] to have tuck shops here or you know, to make a difference on a real level. And then very good idea that we thought would actually work is get together on Friday, 4pm and then maybe do a fashion show from the Elizabeth Galloway place or do an exhibition from the Stellenbosch Academy of Photography and design, then you can even get in a scientist to give a lecture or business men or, it's really interesting what things can come from that. And ja, someone mentioned that a village is something that's sustainable because you know your neighbours and you know your mechanic and you know your lawyer and that kind of thing. And then they also suggested that a body corporate should be implemented, well I said that shouldn't be only driven by money, but then my group said well it's not necessary to be driven by money, but ja, that's what we see in 2015

[s] At the moment there's a bit of experience of competitiveness with certain faculties at the university but we also said there are ways and means of actually turning that into win/win rather than a win/lose competitive relationships. We see this as a rural place, it has a rural feel to it where there's urban agriculture for example going on, where there's lots of green spaces, where you can go up and walk for

lunch after you've been working behind your desk and your computer, where you can sit next to a stream or under a tree but where you also can go and pick the own vegetables that you've actually grown here. We also see here an icon building arising, a real state of the art icon building that will become next to Table Mountain and Kruger Park, the third place that people would want to come and visit and see and experience this icon building and there's lots of creative ideas that would go into that. The Technopark must also be linked with the best and the fastest and IT, broadband type of technology and there's also an expression here that we must be off grid as far as possible using renewable and sustainable energies to achieve that goal. We also see the place being less dense in terms of numbers of people and cars and we would be linked to the other communities through better modes of transport, many ways of transport, bicycle routes, road links and so on, in other words not just an island unto ourselves but links in ways that also support green technologies.

[t] It would be quite nice not to have to leave Technopark, Barbara said that she would love to have a place which was tranquil, serene, a place that didn't really feel like a working environment. What was the kind of future design element that we could incorporate in 5 years' time that made it a special place? What about affordable housing in or near Technopark, because apparently a lot of people from Capitec are driving all the way from Cape Town to go to work here. There's no real public transport in Technopark, what about that aspect. The other thing that was discussed was what kind of companies do we really want here in Technopark, what kind of incentives are we going to use to lure the right kind of companies that we want and how're we going to be the best of the best. How are we going to reduce our carbon footprint, spoke about, but the interesting thing was how're we going to create a symbiotic environment, how're we going to create the spaces for a symbiotic environment and the thing that I found the most interesting was, how are we going to invigorate those companies that are already existing in Technopark to take up this vision and how're we going to use those companies already in Technopark to reach our goals. So there're a lot of engineering companies here, there're a lot of service companies here, there's the municipality etc., how're we going to spread this message so that we can achieve this goal with the companies already existing in Technopark, so that was quite interesting. We had a lot of others, and then finally was management – who is going to take control of this initiative, who is going to drive this initiative and what kind of management are we going to see in 5 years' time.

[u] Several RIS and LIS capacities and capabilities were in beginning phases of development. At the regional level it was institutional and organizational structures that were meant to support the RIS, including the RIF, the EDA, and Green Cape. In the TTP component of the research it also included innovation infrastructures like ICT, and a University incubator for entrepreneurship, and a knowledge centre for student collaboration on campus (Academic A, B 2011).

[v] This was discovered 'first hand' through the investigation by the researcher, but also expressed within the interviews. The TTP project was aimed, in part at investigating the possibility of the co-creation of a vision that would include a strong bias towards sustainability. While establishment of a vision for TP was successful as a process, and as a TD research study, the application of the proposed strategy however, required time to implement. During the researcher's continued involvement after the visioning process was completed, planning for achieving the vision as tangible actions began to take place. In 2015, a new institutional and legal structure was set-up to manage the park towards the vision. The researcher, in his spare capacity assisted the TPOA, to develop a business plan that would enable the park to become a special ratings area (SRA). The SRA which was approved in 2015, created a legal entity that could enforce certain by-laws in partnership with the Municipality, the crux of which was to pay a compulsory levy to service the park. The business plan included the vision and mission for the park to become a sustainability-oriented innovation hub.

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11 Appendices A–E

11.1 APPENDIX A: FOR INTRODUCTION PART

11.1.1 – Appendix (A1) - Important concepts and definitions for this thesis

Innovation - An innovation can be understood as something new that functions and brings value in society. More formally, innovation can be defined as new products, processes and organizational configurations that can be brought to the market.

Socio-cognitive institutions - are the collective bodies of knowledge cultures, as established patterns of information flow and thinking, and the attitudes, norms and values inherent in society.

Sustainable development - is commonly defined as "current generations meeting their needs without exploiting future generations and their ability to meet those same needs." Sustainable development often refers to the integrated performance, development and progress of the triple-bottom line of social, environmental and economic spheres.

Innovation for sustainability – Innovations that are designed for or result in a positive impact for sustainable development, in the short and long term.

Institutions – can be divided into formal and informal institutions. Formal institutions are the laws, regulations, incentives and policies that a region, government may impose. Informal institutions refer to the socially constructed rules, codes of conduct, values and norms developed by and in communities and societies. Often institutions are described as the 'rules of the game' that shape human behaviours and constraints.

Innovation systems - can be defined as the production and diffusion of knowledge in various institutional, political and organizational settings that lead to the development and diffusion of innovations in a specific region, nation state or internationally.

Triple-helix – refers to university, industry and government relations and institutional ties. This is a primary model of a system of innovation.

National and regional innovation systems differ in several respects, firstly, the "national" delineation respects the boundaries, laws, policies and institutions that influence and have a bearing on innovation at a national level; whereas the 'regional' delineation recognizes not only that innovation processes take place more 'regionally' but also that these processes are

embedded in networks that may span across nations, and often internationally. The effects of proximity and geography on innovation are more prominent in the regional innovation systems literature.

Sustainability-oriented innovation systems – are the production and diffusion of knowledge in various institutional, political and organizational settings that lead to the development and diffusion of innovations in a specific region, nation, state, or beyond and that contribute to sustainable development goals and processes.

SoIS, differ from conventional innovation systems in that the focus of innovation is on sustainability and not purely economic growth. SoIS ensure the practice, process and outcomes of innovation follow principles of sustainability, but also produce and encourage innovative products, technologies and processes that enable greater sustainability.

Socio-technical – the fusion of social systems with technological systems as one conceptual unit.

Transformations to sustainability – the incremental and partial shift in socio-technical systems or regimes towards more sustainable socio-technical systems or regime growth trajectories.

Socio-economic pathways - like socio-technical pathways are specific trajectories of development with inertia. This means they are rigid to change, but they can be shifted through innovation – both social and technical innovation.

Socio-technical transitions can be defined as: 'a set of processes that lead to a fundamental shift in socio-technical systems' (Markard et al. 2012b:956).

Sustainability transitions then can be defined as the shift of socio-technical systems to more sustainable socio-technical systems – or 'long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption' (Markard et al. 2012b:956).

11.1.2 – Appendix (A2) - Letter for ethical clearance

UNIVERSITEIT·STELLENBOSCH·UNIVERSITY
jou kennisvennoot • your knowledge partner

25 March 2011

Tel.: 021 - 808-9183
Enquiries: Sidney Engelbrecht
Email: sidney@sun.ac.za

Mr. P van Heyningen
School of Public Leadership
University of Stellenbosch
STELLENBOSCH
7600

Reference: 498/2011

Mr. P van Heyningen

APPLICATION FOR ETHICAL CLEARANCE

With regards to your application, I would like to inform you that the project, *Determining the factors of sustainability orientated innovation - Stellenbosch*, has been approved on condition that:

1. The researcher/s remain within the procedures and protocols indicated in the proposal;
2. The researcher/s stay within the boundaries of applicable national legislation, institutional guidelines, and applicable standards of scientific rigor that are followed within this field of study and that
3. Any substantive changes to this research project should be brought to the attention of the Ethics Committee with a view to obtain ethical clearance for it.
4. The researcher/s implements the suggestions made by the mentioned by the Research Ethics Committee (Human Research) in order to reduce any ethical risks which may arise during the research.

We wish you success with your research activities.

Best regards

DIE UNIVERSITEIT VAN STELLENBOSCH
25 MAR 2011
THE UNIVERSITY OF STELLENBOSCH

SFengelbrecht
.....
MR SF ENGELBRECHT
Secretary: Research Ethics Committee: Human Research (Non-Health)

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11.2. APPENDIX B: FOR PART 1

11.2.1 Appendix (B1) – A model of the stage of the innovation process

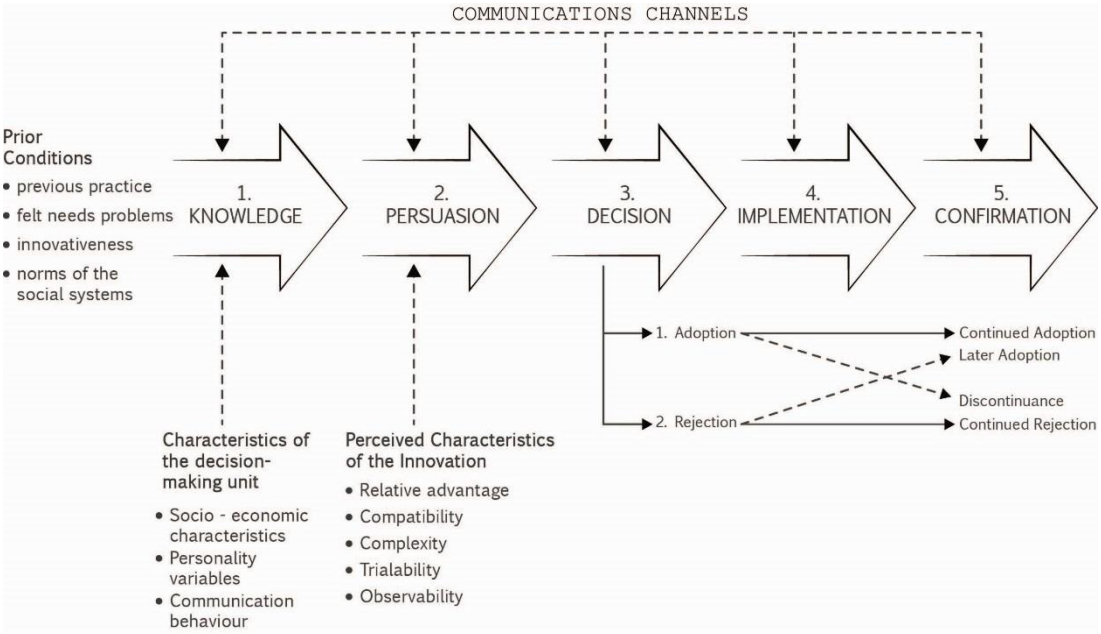


Figure B1 A model of the stages in the innovation decision process

11.2.2 Appendix (B2) - The innovation S-curve adoption ratio

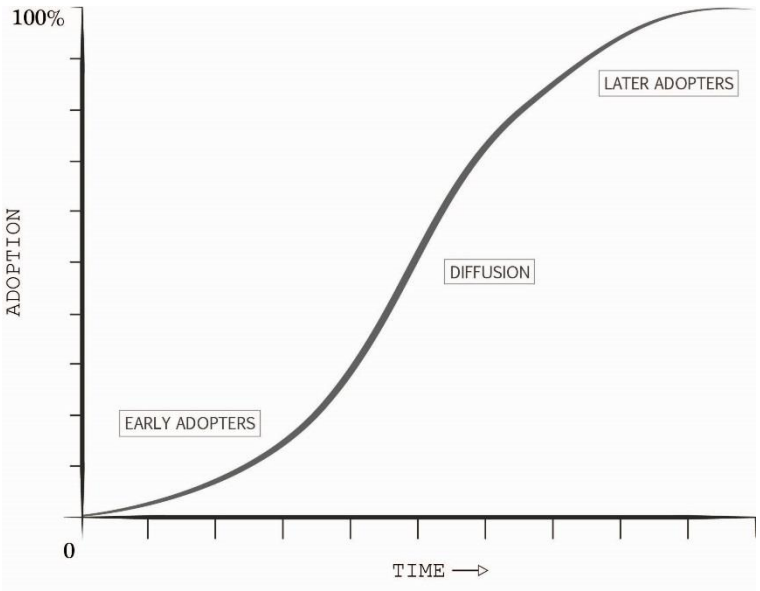


Figure B2: The innovation S-curve adoption ratio (Adapted from Rogers, 1983)

11.2.3 – Appendix (B3) - Functions of innovation systems

Functions of innovation systems	Is the process of strengthening:
1. ***Knowledge development and diffusion…***	*the breadth and depth of the knowledge base and how that knowledge is developed, diffused and combined in the system.*
2. ***Entrepreneurial experimentation . . .***	*the testing of new technologies, applications and markets whereby new opportunities are created and a learning process is unfolded.*
3. ***Influence on the direction of search . . .***	*The incentives and/or pressures for organisations to enter the technological field. These may come in the form of visions, expectations of growth potential, regulation, articulation of demand from leading customers, crises in current business, etc.*
4. ***Resource mobilization . . .***	*the extent to which actors in the TIS are able to mobilise human and financial capital as well as complementary assets such as network infrastructure.*
5. ***Market formation . . .***	*the factors driving market formation. These include the articulation of demand from customers, institutional change, changes in price/performance. Market formation often runs through various stages, i.e. ''nursing' or niche markets, e.g. in the form of demonstration projects, bridging markets and eventually mass markets.*

6. Legitimation . . .	*the social acceptance and compliance with relevant institutions. Legitimacy is not given but is formed through conscious actions by organisations and individuals.*
7. Development of positive externalities . . .	*the collective dimension of the innovation and diffusion process, i.e. how investments by one firm may benefit other firms 'free of charge'. It also indicates the dynamics of the system since externalities magnify the strength of the other functions.*

Table B3. Functions of innovation systems (Bergek et al. 2008)

11.2.4 Appendix (B4) - A dynamics model of the MLP process

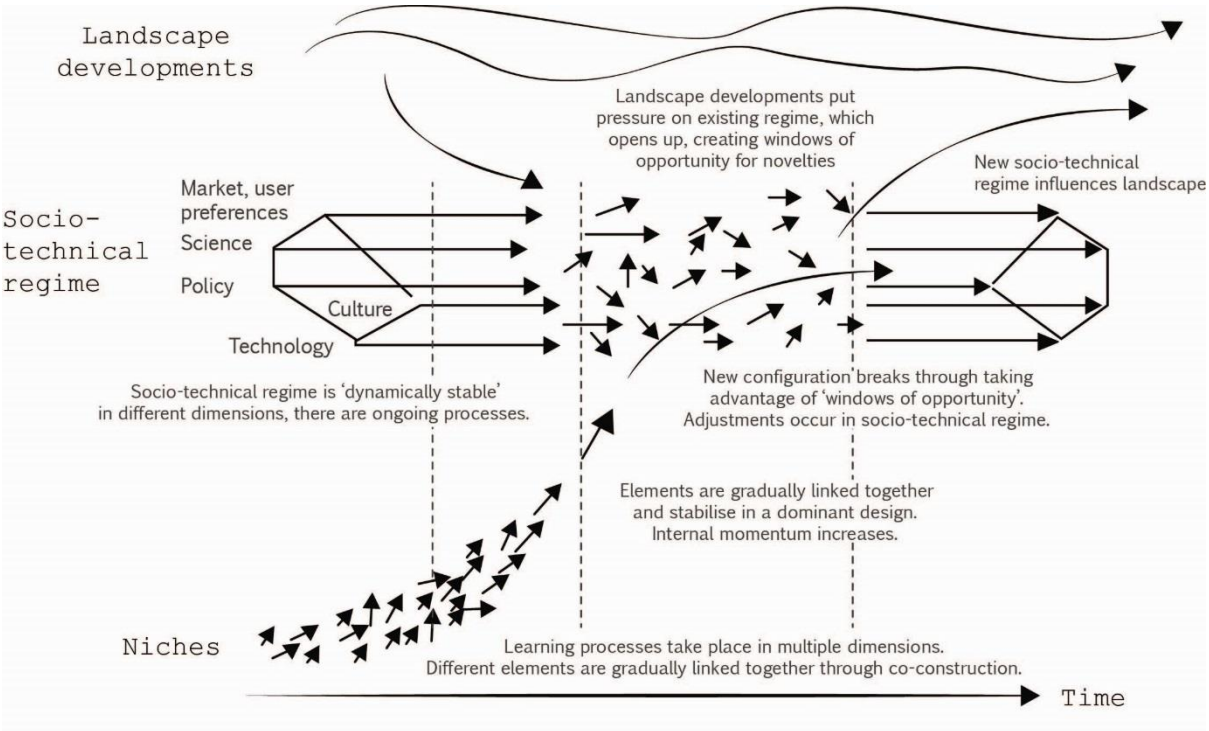


Figure B4. A dynamic model of multi-level perspectives (Genus & Coles 2008: 1438)

11.3 APPENDIX C: FOR PART 2

11.3.1 – Appendix (C1) - Literary deductive framework of RIS characteristics and coding categories

RIS Elements [El]

Coding categories	*Leading Authors*

▪ [El/Connect] : Level of connectedness between elements
▪ [El/Firms] : Their connectedness/ collaboration/ cohesion
  ○ Horizontal networking (Inter-firm)
  ○ Vertical networking (suppliers to customers)
▪ [El/Institutions] : Formal vs. informal - apparent strengths, thickness, thinness, lock-in
  ○ Durability/ rigidity
  ○ trust
  ○ support for innovation
  ○ sustainability
▪ [El/K&I,Infra] Knowledge and innovation infrastructure:
  ○ Evidence of spatial-innovation support structures
  ○ Evidence of knowledge and innovation exchange structures/ organizations (e.g.
  ○ Research and development (R&D) structures
  ▪ Indicators of public R&D
  ▪ Indicators of private R&D
  ▪ Hybrid or joint R&D
▪ [El/Policies] : Evidence of regional innovation policies
▪ [El/Integration] : Evidence of regional integration/ social order
	Cooke et al 1997/2000
	Doloreux & Parto 2004/2005
	Asheim & Isaksen 2002
	Coenen et al. 2004
	Moodysson et al. 2008
	Malmberg & Maskell 1997/ 2006
	Asheim 1996
	Asheim & Gertler 2006
	Doloreux 2002
	Boschma 2005
	Lorenzen 2005
	Tödtling & Trippl (2005)

Table C1 Literary deductive framework of RIS characteristics and coding categories

11.3.2 – Appendix (C2) – Literary deductive framework for RIS Elements

RIS Elements [El]

Coding categories	*Leading Authors*

▪ [El/Connect] : Level of connectedness between elements
▪ [El/Firms] **:** Their connectedness/ collaboration/ cohesion
  ○ Horizontal networking (Inter-firm)
  ○ Vertical networking (suppliers to customers)
▪ [El/Institutions] **:** Formal vs. informal - apparent strengths, thickness, thinness, lock-in
  ○ Durability/ rigidity
  ○ trust
  ○ support for innovation
  ○ sustainability
▪ [El/K&I, Infra] **Knowledge and innovation infrastructure:**
  ○ Evidence of spatial-innovation support structures
  ○ Evidence of knowledge and innovation exchange structures/ organizations
  ○ Research and development (R&D) structures
  ▪ Indicators of public R&D
  ▪ Indicators of private R&D
  ▪ Hybrid or joint R&D
▪ [El/Policies] **: Evidence of regional innovation policies**
▪ [El/Integration] **: Evidence of regional integration/ social order**
	Cooke et al 1997/2000
	Doloreux & Parto 2004/2005
	Asheim & Isaksen 2002
	Coenen et al. 2004
	Moodysson et al. 2008
	Malmberg & Maskell 1997/ 2006
	Asheim 1996
	Asheim & Gertler 2006
	Doloreux 2002
	Boschma 2005
	Lorenzen 2005
	Tödtling & Trippl (2005)

Table C2. Literary deductive framework for RIS Elements

11.3.3 – Appendix (C3) – Literary deductive framework for RIS Mechanisms

RIS Mechanisms [Mech]

Coding categories	*Leading Authors*
▪ [Mech/connected] **:** Indications of connectedness of mechanisms	Authors same as above
▪ [Mech/Int + learning]: Interactive learning (in proximity)?	
○ Codified/Ubiquitous knowledge	
○ Tacit knowledge	
○ Vertical learning (inputs and outputs of firms)	
○ Horizontal learning (knowledge networks/ trade networks/ user-producer networks)	
○ Observability/ Comparability/ Neighbourhood effect (role of spatial proximity)	
▪ [Mech/Prox]: Proximities	
○ [Prox/spatial : Spatial (same as geographic)	
○ [Prox/cog] : Cognitive	
○ [Prox/Org] : Organizational proximity	
○ [Prox/Social] : Social proximity/ trust networks	
○ [Prox/Instit] : Institutional proximity	
○ Geographic proximity [N/A – included in above coding]	
○ Functional proximities [N/A – included in above coding]	
○ Relational proximities [N/A – included in above coding]	
▪ [Mech/Embed : Embeddedness	
▪ [Mech/Know prod.] : Knowledge production	
▪ [Mech/Financing Financing (Evidence of type/ approach to financing/ level)	

Table C3. Literary deductive framework for RIS Mechanisms

11.3.4 – Appendix (C4) – Literary deductive framework for RIS and SIS industry characteristics

Measuring the type (Sector/cluster) kind of RIS/ characteristics [SIS]

Coding categories	*Leading Authors*

▪ [SIS/change] **: Change/transformation with the sector(s)?**
▪ [SIS/Links] **: Links, interdependencies, boundaries of the sectors?**
▪ [SIS/Env + Shaped] **: Evolutionary perspectives** (how is the sector shaped by the environment within which agents act i.e. institutions, culture, knowledge and belief systems).
  ◦ External shocks to the system?
  ◦ Availability of basic knowledge
▪ [SIS/M1] **: Evidence of Mark I** (ease of entry, many smaller new firms, innovative and entrepreneurial activity)
▪ [SIS:M2] **: Evidence of Mark II** (Dominant, incumbents, creatively accumulate, innovate incrementally)
	Malerba 2002/5
	
	Howells and Roberts 2000

Table C4. Literary deductive framework for RIS and SIS Industry Characteristics

11.3.5 – Appendix (C5) – Literary deductive framework for functions of IS

Functions of Innovation Systems [Func]

Coding	*categories*
Leading Authors	
▪ [*Func/Knowledge Dev] **: Knowledge development and diffusion**	Carlsson & Stankiewicz 1991
▪ [Func/ Entrep Exp] **: Entrepreneurial experimentation**	Markard & Truffer 2008
▪ [Func/Search] **: Influence on the direction of search**	
▪ [Func/ Resources Mob] **: Resource mobilization**	
▪ [Func/ Market Form] **: Market formation**	Bergek et al. 2008
▪ [Func/ Legit] **: Legitimation**	Hekkert et al. 2007
▪ [Func/ Pos + Ext] **: Development of positive externalities**	

Table C5. Literary deductive framework for Functions of IS

11.3.6 – Appendix (C6) - Literary deductive framework for RIS Strengths, weaknesses and capabilities

Measuring the strength and weaknesses of RISs [Fail]

[If essential organizations are lacking it may cause *system failures* as 'missing actors'. *Rule* failure for example may be when industrial policy is too strict, or cultures to risk averse (institutional failure) or when networks between firms are not functional (network failure)].

Coding categories	*Leading Authors*
▪ [Fail/Infra] **: Infrastructural Failures** ○ Lack of physical infrastructures supporting innovation ○ Science and Technology infrastructure	Tödtling & Trippl 2005
▪ [Fail/Instit] **: Institutional Failures** ○ **Hard Institutional Failures** (standards, laws, legal systems, policies etc.) ○ **Soft Institutional Failures (**refer to the socio-political sphere, where society shares rules, norms, culture and values)	Bjorn T. Asheim et al. 2011 Oltra & Saint Jean 2009
▪ [*Fail/Interact] **: Interaction Failures [Lock-in]** ○ Weak network failures (too little interaction) ○ Strong network failures (too much interaction) resulting in 'lock-in' ○ Myopia (too much group think) ○ Successful networks (hot spots) may well develop into unsuccessful ones (blind spots) due to ignorance of relevant developments outside"	Klein Woolthuis et al. 2005 Cooke et al. 1997 Doloreux & Parto 2004
▪ [Fail/Capab] **: Capabilities failures** ○ Lack resources, capacities and capabilities to innovate or adopt new technologies. (Transition failures, lack of ability to transition to new technologies or technological paradigm).	

▪ [Fail/Specialization] **: Firm weakness** (lack of specialization of a region) ▪ [*Fail/Instit weak] **: Institutional weakness and rigidity** (A region that has weak ties between organizations, and a thin organizational culture of cooperation and innovation) ▪ [*Fail/Know Inf] **: Weak knowledge and innovation infrastructure** ▪ [*Fail/Policy] **: Weak policy and governance**	Tödtling & Trippl (2005) Bjorn T. Asheim et al. 2011 Oltra & Saint Jean 2009 Klein Woolthuis (et al. 2005) Cooke et al. 1997 Doloreux & Parto 2004

Table C6. Literary deductive framework for RIS Strengths, weaknesses and capabilities

NB. Please note that codes with * are very similar in category to previous codes. There do however, exist slight differences, and thus they are included for this purpose if required in the reflexive analysis of the literature.

11.3.7 – Appendix (C7) - Theme 1: Literary deductive framework and sub-research questions

Theme I – Capacity of regional innovation systems

Sub-Propositions:

Sub-P1a: Strong and functional RISs have a greater capacity to enable socio-economic transitions to sustainability.

Sub-P1b: Weak RISs, have less capacity to produce and diffuse innovations, and hence enable socio-economic transitions to sustainability.

Sub-Research Questions 1:

Sub-RQ1a: Do strong and functional RISs have a greater capacity to enable socio-economic transitions to sustainability?

- *How are the capacities and capabilities of RISs measured?*
- *How do capabilities and capacities translate into more functional RISs?*
- *How do more functional and capable RISs provide the opportunity for socio-economic transition pathways?*
- *What evidence is there of capabilities of RISs having an influence on transitions pathways?*

Sub-C1a: Literary Indicators/ Coding categories:

Evidence of a strong RIS [1: RIS Strong: Infra/ Instit/ Interact/ Capab/ Specialization/ Instit weak/ Know Inf/ Policy

Evidence of a functional RIS [1: RIS Func: Knowledge dev/ Entrep Exp/ Search/ Resource Mob/ Market form/ Legit/ Pos Ext

Evidence of type of SIS [1: SIS: Change/ Links/ Env + Shaped/ M1/M2]

Sub-RQ1b: Do weak RISs have less capacity to influence socio-economic transitions to sustainability?

Is there evidence where low capabilities or weaknesses in the RIS constrain ability for socio-economic transition pathways?

Sub-P1b Indicators/ Coding categories:

Evidence of weak [*case] [1: RIS Weak: Infra/ Instit/ Interact/ Capab/ Specialization/ Instit weak/ Know Inf/ Policy]

Evidence of dysfunctional [*case] [1: RIS DysFunc: Knowledge dev/ Entrep Exp/ Search/ Resource Mob/ Market form/ Legit/Pos Ext]

Additional Inductive, Abductive and Ethnographic "levels" of Analysis & 2ndary Data Analysis

Inductive 'unconstrained' ethnographic Analysis:

Developing 'inductive' categories if required

Evidence/ examples of socio-economic transitions to sustainability as result of RIS

Evidence/ examples of socio-economic transitions to sustainability being constrained as result of weak RIS

Observable, factual or secondary data evidence for link between capacities, capabilities of RIS and ability to influence socio-economic trajectories in [*Case].

Table C7. Theme 1: Literary deductive framework and sub-research questions

11.3.8 – Appendix (C8) - Literary deductive framework and sub-research questions

Investigative Theme II – Socio-Cognitive Institutions + Direction of RIS (i.e. SoIS)

Sub-Propositions 2:

Sub-H2a: Socio-cognitive institutions are a primary enabling factor for determining the direction of innovation within RIS as a system.

Sub-H2b: Socio-cognitive institutions are a primary constraining factor for determining the direction of innovation within RIS as a system.

Sub-Research Questions 2:

Sub-RQ2a: How do *SCIs* within RISs have an influence on the direction and qualities of innovation outputs in the regional/local economy?

- What is the role of Socio-cognitive institutions in the elements of RIS:
  - *Role of SCIs between and within elements:* [2:SCI El: connect/ firms/ institutions/ K&I, Infra/ Policies/ Integration]
- What is the role of socio-cognitive institutions in the mechanisms and proximities of RIS:
  - *Role of SCIs between and within mechanisms and proximities in RIS:* [2:SCI Mech: Embed/ know prod/ financing]
  - *Role of SCIs and proximities in RIS:* 2:SCI Mech/Prox: spatial/ cog/ org/ social/ instit]
- How do *SCIs* in RIS have an influence on the direction of innovation outputs? [Evidence in the case]
  - Is there historical evidence of changing or new *SCIs* supporting SD [Austrian Case] [2:Hist/SCI/Innovation]
  - Is there evidence of changing visions for sustainable development [Austrian/ Stellenbosch Case] [2:Visions/SCI change to SD]
  - Is there evidence of rigid *SCIs* that hamper change in direction of RIS or innovation outcomes? [2:Rigid RIS SCI/ Lock-in]
- Is there a connection between the qualities of *SCIs* affecting the qualities of innovation outputs i.e. towards a sustainable outcome or direction?
  - Is there evidence of *SCIs* affecting innovation outputs towards a sustainability direction? [2:Qualities SCI/SD]

Sub-RQ2b: To what extent are socio-cognitive institutions a determining factor for sustainability-oriented innovation systems resulting in pathways for socio-economic transitions?

- Are SCIs a primary influencing factor in the direction of RISs? [2:SCI as primary influence]
- What influences SCIs in RISs? [2:Influence of SCI in RIS]

What are other possible influencing factors in the direction of RISs? [2:Other influence of SCI/RIS]

Additional Inductive, Abductive and Ethnographic "levels" of Analysis & 2ndry Data Analysis

Inductive 'unconstrained' ethnographic Analysis:

This is to find any additional categories that can be included into the overarching analysis framework that may shed light on the sub and main research questions. This also includes perspectives and observations of the researcher who was involved in the research process.

Observable, factual or secondary data evidence for link between socio-cognitive institutions in RIS and resultant pathways to socio-economic transitions.

Table C8. Theme 2: Literary deductive framework and sub-research questions

11.3.9 – Appendix (C9) - Literary deductive framework and sub-research questions

Investigative Theme III

Multi-level structures and multi-scalar analysis in SCI formation

Sub-Proposition:

Sub-P3a: Socio-cognitive institutions exist and are shaped differently by various forms of proximities on different structural and scale levels. [i.e. SCI are influenced by degrees of structuration and distance of proximities, but may also differ at different structural and scale levels].

Sub-research questions 3:

How do socio-cognitive institutions exist and how are they shaped by various forms of proximities on different structural and scale levels?

- Are the qualities of SCIs different on different structural levels (i.e. macro, meso, micro)?
    - *Qualities on a macro level* 3:Macro Qualities SCI/SD]
    - *Qualities on a meso level* [3:Meso Qualities SCI/SD]
    - *Qualities on a micro level* [3:Micro Qualities SCI/SD]
    - *Qualities dynamically influenced (e.g. events on the macro-level)* [3:Dynamic levels SCI/SD]
- How may *SCIs* be shaped through various forms of proximities at multiple [ML] structural and scale levels?
    - *Spatial proximities [3: ML Shaped/spatial]*
    - *Cognitive proximities [3: ML Shaped/Cognitive]*
    - *Institutional proximities [3: ML Shaped/Insit]*
    - *Organizational proximities [3: ML Shaped/Org]*
    - *Social proximities [3: ML Shaped/social]*
- *To what extent does spatial proximity play a role in the formation of SCIs of a particular kind?*
- *Is there evidence of rigidity [Lock-in] in institutional structures at different levels?*
        - *Formal* [3:Formal lock-in Macro/meso/micro]

- *Informal* [3:Informal lock-in Macro/meso/micro]

Is there evidence of localized learning towards sustainability? [3:Localized Learning for SD]

Additional Inductive, Abductive and Ethnographic 'levels' of Analysis & 2ndary Data Analysis

Sub-P3a: Indicators [Abductive Analysis i.e. latent content]:

- What evidence is there for socio-cognitive institutions being shaped by socio-spatial proximities?

Is there evidence of relations between the formation of socio-cognitive institutions on structural levels (i.e. embeddedness of networks in RIS) and socio-spatial scalar levels?

Inductive 'unconstrained' ethnographic Analysis:

This is to find any additional categories that can be included into the overarching analysis framework that may shed light on the sub and main research questions. This also includes perspectives and observations of the researcher who was involved in the research process.

Observable, factual or secondary data evidence for link between socio-cognitive institutions in RIS and resultant pathways to socio-economic transitions.

Table C9. Theme III Literary deductive framework and sub-research questions

11.3.10 – Appendix (C10) - Theme I Deductive coding Matrix for the Content Analysis

Theme I - Capacities of RIS

Sub-RQ1a:

Do strong, capable and functional RISs have a greater capacity to enable socio-economic transitions to sustainability?

Code Categories from Sub-Research Questions	Primary Codes	Sub-codes
Capacity & Capabilities *Assessing the capacity and capabilities of RIS, and type of SIS*	**1. Strong RIS** 1a:Strong RIS	Infra/ Instit/ Interact/ Capab/ Specialization/ Know Inf/ Policy
	2. Functional RIS 1a:Func RIS:	Knowledge dev/ Entrep Exp/ Search/ Resource Mob/ Market form/ Legit/ Pos Ext
	3. Type of SIS 1a:SIS	Change/ Links/ Env + Shaped/ M1/M2

Sub-RQ1b: Do weak RISs have less capacity to influence socio-economic transitions to sustainability?

Code Categories from Sub-Research Questions	Codes	Sub-sub-codes
RIS Weaknesses, Failures & Function Failures *Assessing the general weaknesses and failures of RIS*	**4. Weak RIS** 1b:Weak RIS	Infra/ Instit/ Interact/ Capab/ Specialization/ Instit weak/ Know Inf/ Policy

	5. Function failures in RIS 1b:Func Fail RIS:	Knowledge dev/ Entrep Exp/ Search/ Resource Mob/ Market form/ Legit/ Pos Ext

Table C10. Theme I Deductive coding Matrix for the Content Analysis

11.3.11 – Appendix (C11) - Deductive coding Matrix for the Content Analysis

THEME II: Socio-cognitive institutional formation, direction and influence

Sub-RQ2a: How do *SCIs* within RISs have an influence on the direction and qualities of innovation outputs in the regional/local economy?

Code Categories from Sub-Research Questions	**Primary-Codes**	**Sub-codes**
SCI Formation *Role of SCIs between and within elements)*	**6. SCI & Elements of RIS** 2a:SCI El	2a:SCI El: connect/ firms/ institutions/ K&I, Infra/ Policies/ Integration]
SCI Formation *Role of SCIs between and within mechanisms in RIS*	**7. SCI & Mechanisms of RIS** 2a:SCI Mech	2a:SCI Mech: Embed/ know prod/ financing]
SCI Formation *Role of SCIs between and within proximities in RIS*	**8. SCI & Proximities** 2a:SCI Prox	2a:SCI Prox: spatial/ cog/ org/ social/ instit]
SCI + Direction *Is there historical evidence of changing or new SCIs supporting SD*	**9. Historical evidence of changing SCI** 2a:Hist/SCI/Innovation	2a:Hist/SCI/Innovation

SCI + Visions *Is there evidence of changing visions for sustainable development*	**10. New visions for sustainability** 2a:Visions/SCI	2:Visions/SCI change to SD
SCI + Lock-in *Is there evidence of rigid SCIs that hamper change in direction of RIS or innovation outcomes?*	**11. Lock-in, rigid SCI** 2a:Rigid SCI in RIS	2:Rigid RIS SCI/ Lock-in
SCI + Qualities *Is there evidence of SCIs affecting innovation outputs towards a sustainability direction?*	**12. Qualities/Outputs** 2a:Qualities SCI/SD	2:Qualities SCI/SD

Sub-RQ2b: To what extent are socio-cognitive institutions a determining factor for sustainability-oriented innovation systems resulting in pathways for socio-economic transitions?

Code Categories from Sub-Research Questions	**Primary Codes**	**Sub-codes**
SCI + Influence *Are SCIs a primary influencing factor in the direction of RISs?*	**13. SCI Primary influence** 2b:SCI Primary influence	2b:SCI Primary influence
SCI + Influence of *What influences SCIs in RISs?*	**14. SCI Influence** 2b:Influence SCI in RIS	2b:Influence SCI in RIS

Other Influence of	**15. Other Influence**	2b:Other influence SCI/RIS
What are other possible influencing factors in the direction of RISs?	2b:Other influence of RIS	

Table 12.11. Theme II Deductive coding Matrix for the Content Analysis

11.3.12 – Appendix (C12) - Deductive coding Matrix for the Content Analysis

Theme III - SCI Formation, Structure & Scale

Sub-research questions 3: How do socio-cognitive institutions exist and how are they shaped by various forms of proximities on different structural and scale levels?

Code Categories from Sub-Research Questions	**Primary Codes**	**Sub-codes**
Qualities + Structural levels *Are the **qualities** of SCIs different on different **structural levels** (i.e. macro, meso, micro)?*	Multi-level shaped Qualities 3:ML Shaped Qualities	3:Macro Qualities SCI/SD *Qualities on a macro level* 3:Meso Qualities SCI/SD *Qualities on a meso level* 3:Micro Qualities SCI/SD *Qualities on a micro level* 3:Dynamic levels SCI/SD *Qualities dynamically influenced*
Proximities + Structural and Scalar *How may SCIs be **shaped** through various **forms of proximities** at different **structural and scale levels?***	3:ML Shaped Proximities	3: ML Shaped/spatial 3: ML Shaped/Cognitive 3: ML Shaped/Insit 3: ML Shaped/Org 3: ML Shaped/social

SCI + Spatial Proximity *To what extent does spatial proximity play a role in the formation of SCIs of a particular kind?*	**SCI + Spatial Proximity** 3: SCI + Spatial Proximity	3: SCI + Spatial Proximity
Lock-in + Levels (Spatial & structural) *Is there evidence of rigidity [Lock-in] in institutional structures at different levels and spatial scales?*	**Formal Lock-in** 3:Formal lock-in **Informal Lock-in** 3:Informal lock-in	3:Formal lock-in Macro/meso/micro 3:Informal lock-in Macro/meso/micro
Localized Learning for SD *Is there evidence of localized learning towards sustainability?*	**Localized Learning for SD** 3:Localized Learning for SD	3:Localized Learning for SD

Table C12. Theme III Deductive coding Matrix for the Content Analysis

11.3.12 – Appendix (C13) – The content analysis process

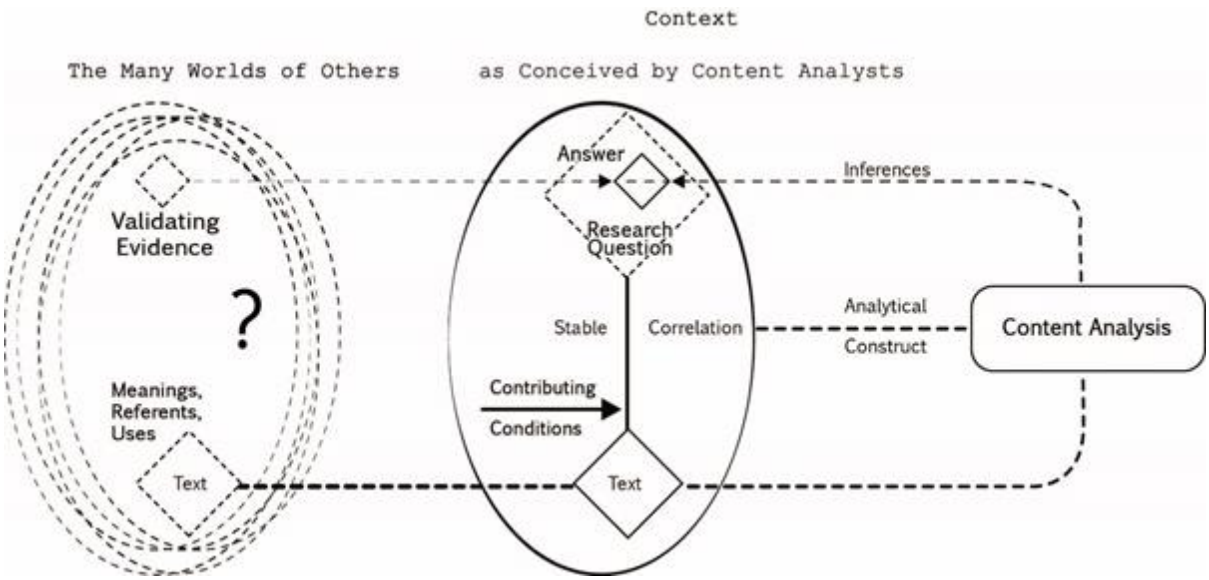


Figure C13. The content analysis process

11.4 APPENDIX D: FOR PART III - Austria

11.4.1 D1 – E-file Austrian Case [Please request from the researcher]

11.4.2 D2 – E-File South African Case [Please request from the researcher]

11.4.3 D3 – Theme codes 1-3, and inductive codes

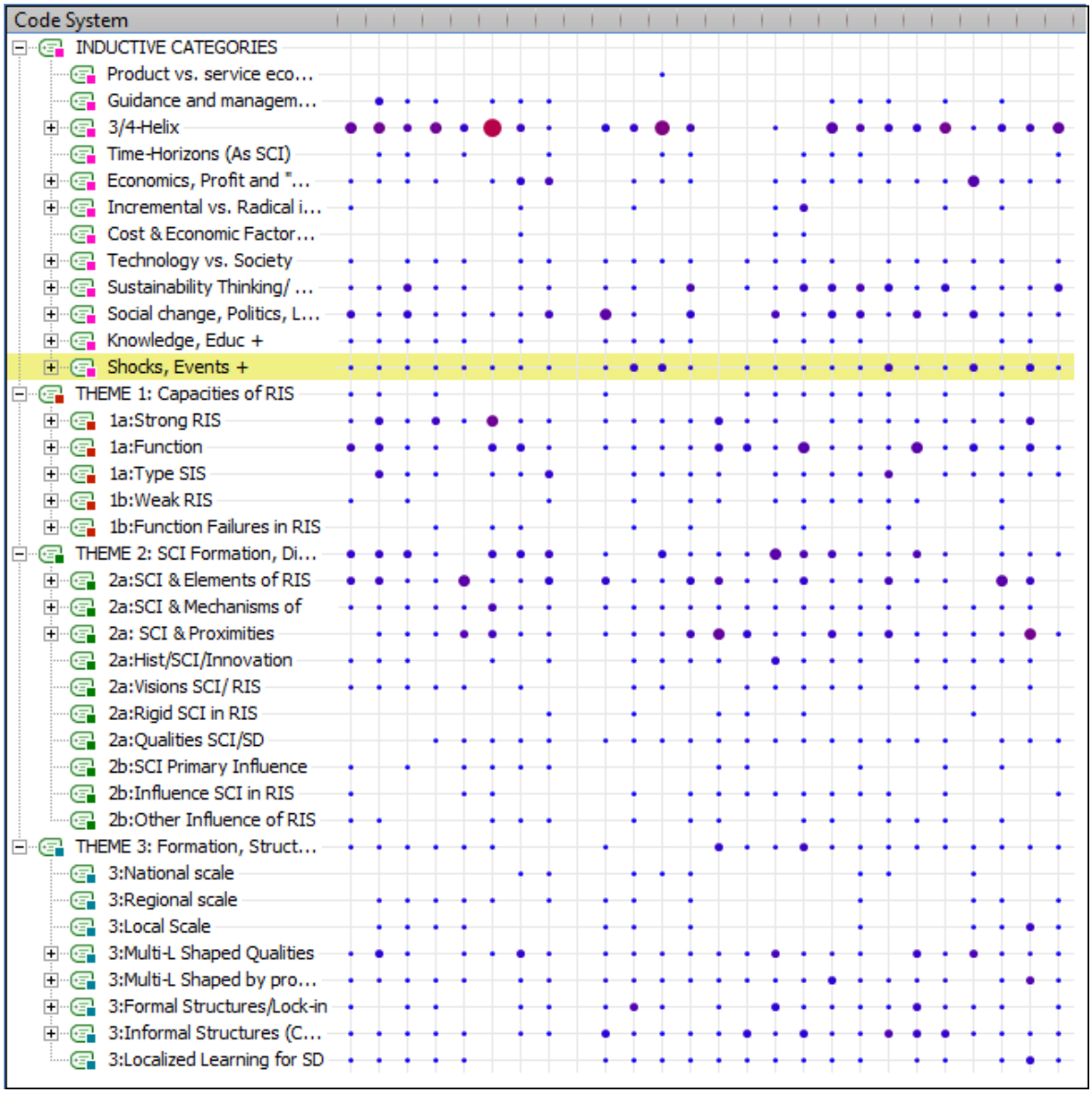


Figure D3. Theme codes 1-3, and Inductive codes

11.4.4 – Appendix (D4) - Respondents

Styria: Intermediaries & Civil Organizations	Respondents: A – J
Styria: Academics & Researchers	Respondents: K – R
Stryia: Private Sector	Respondents: S – Y

11.4.5 D5 - Results of the coded segments Austria, Theme I

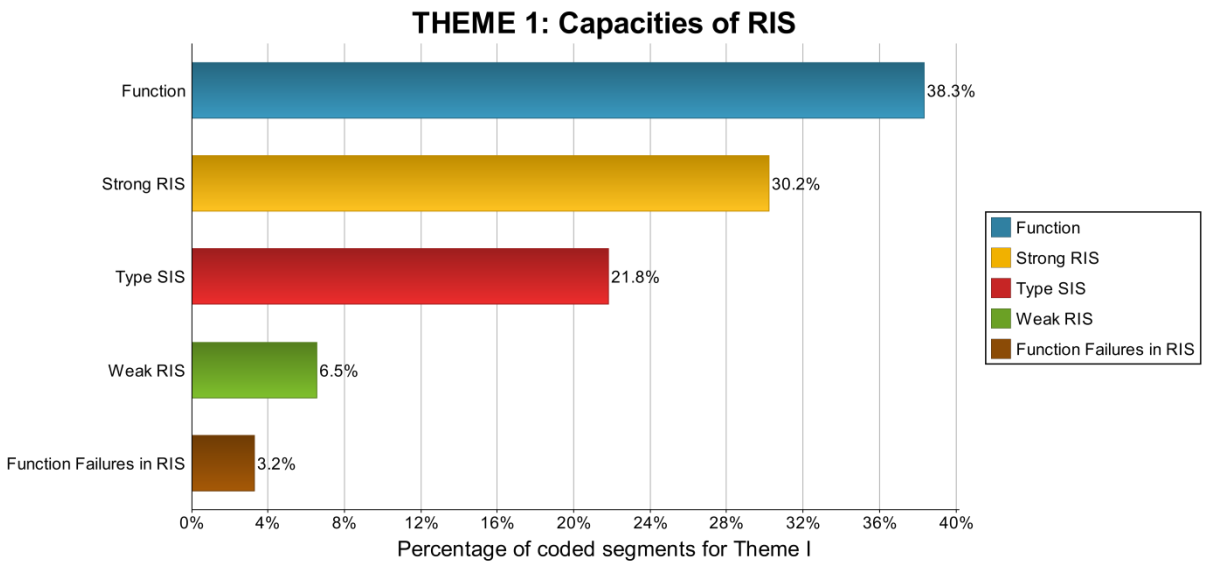


Figure D5. Results of the coded segments Austria, Theme I.

Below a more detailed graphic image from MaxQDA, shows the various primary coding categories, and sub-codes against the summary of the data that has been retrieved (blue dots).

11.4.6 D6 – Graphic results of the coded segments Austria, Theme I

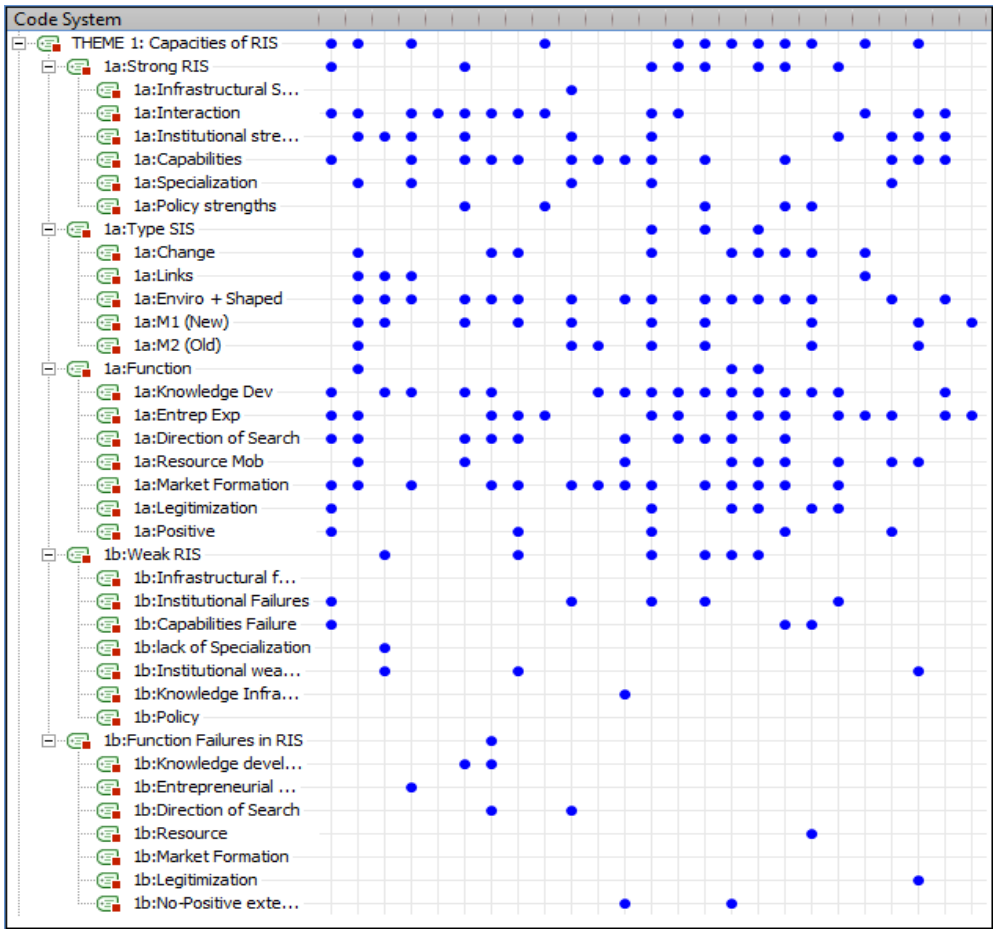


Figure D6. Theme I – Austria Codes

11.4.7 – Appendix (D7) – Austria Theme II Codes

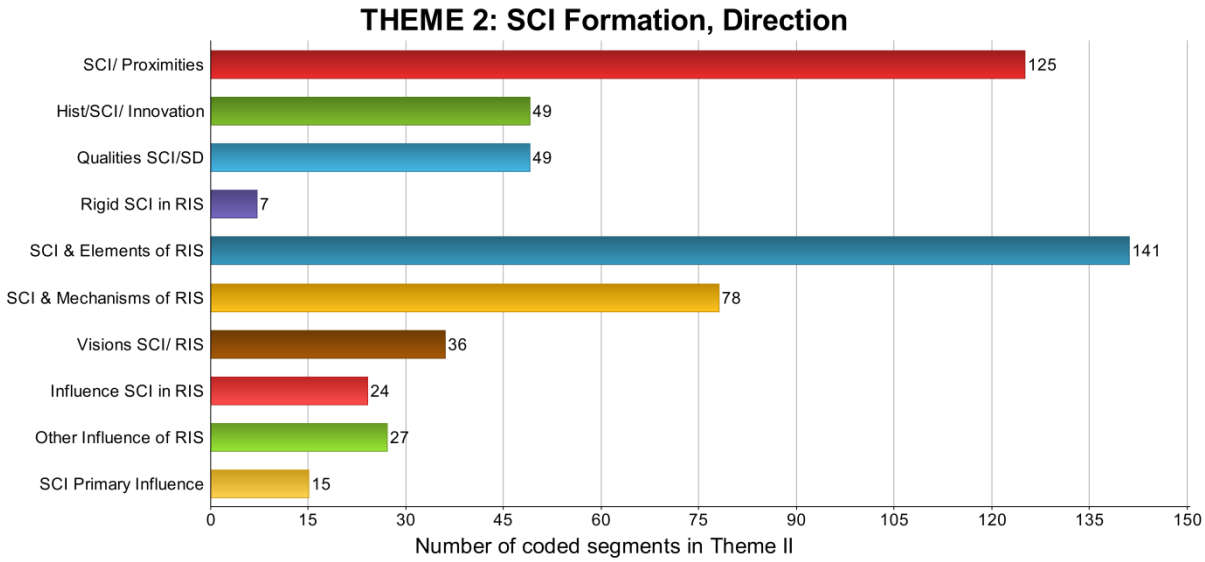


Figure D7. Theme 2: SCI Formation and direction

11.4.8 - Appendix (D8) – Graphic results of the coded segments Austria, Theme II

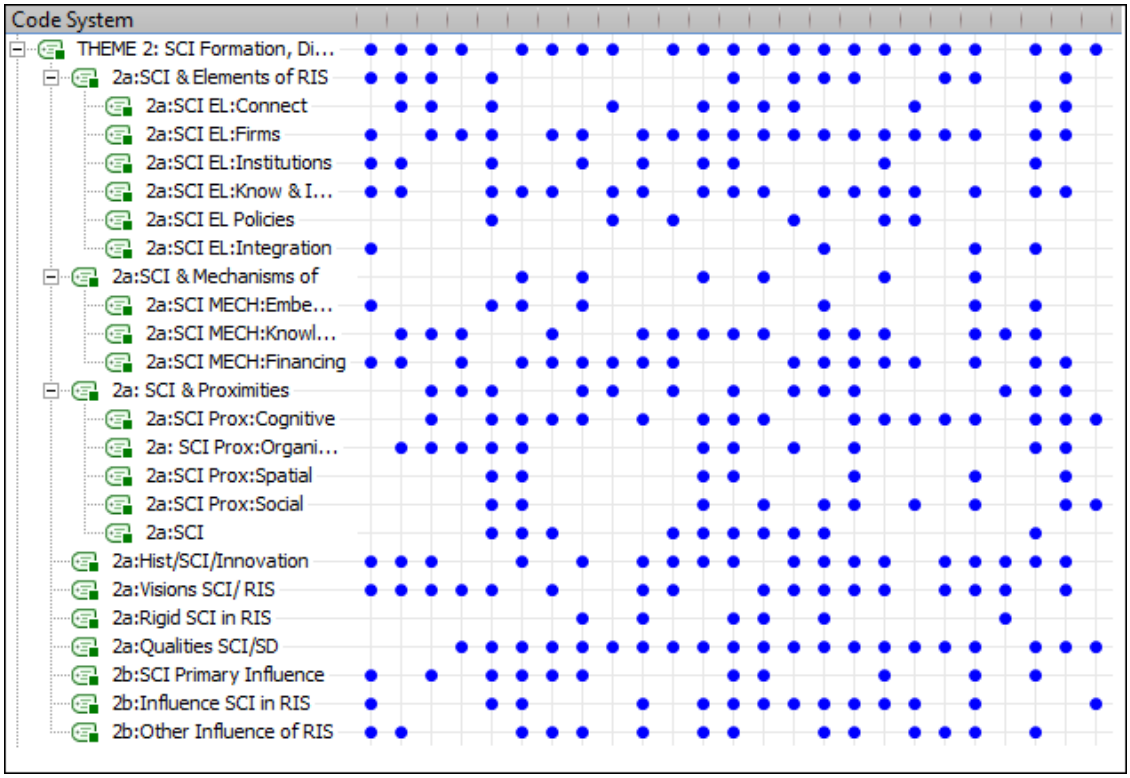


Figure D8 – Austria Codes Theme II

11.4.9 – Appendix (D9) – Austria Theme III

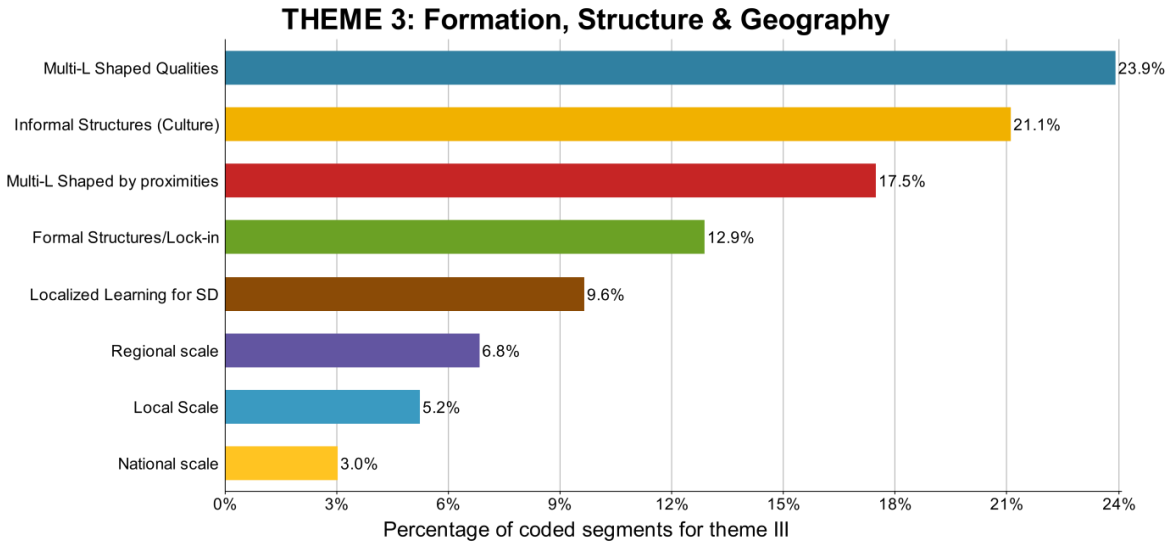


Figure D9. Theme 3: Formation, structure and geography

The figure below provides a more detailed breakdown of codes, and sub-codes versus the document texts. The document texts represent interviews with respondents.

11.4.10 - Appendix (D10) – Graphic results of the coded segments Austria, Theme III

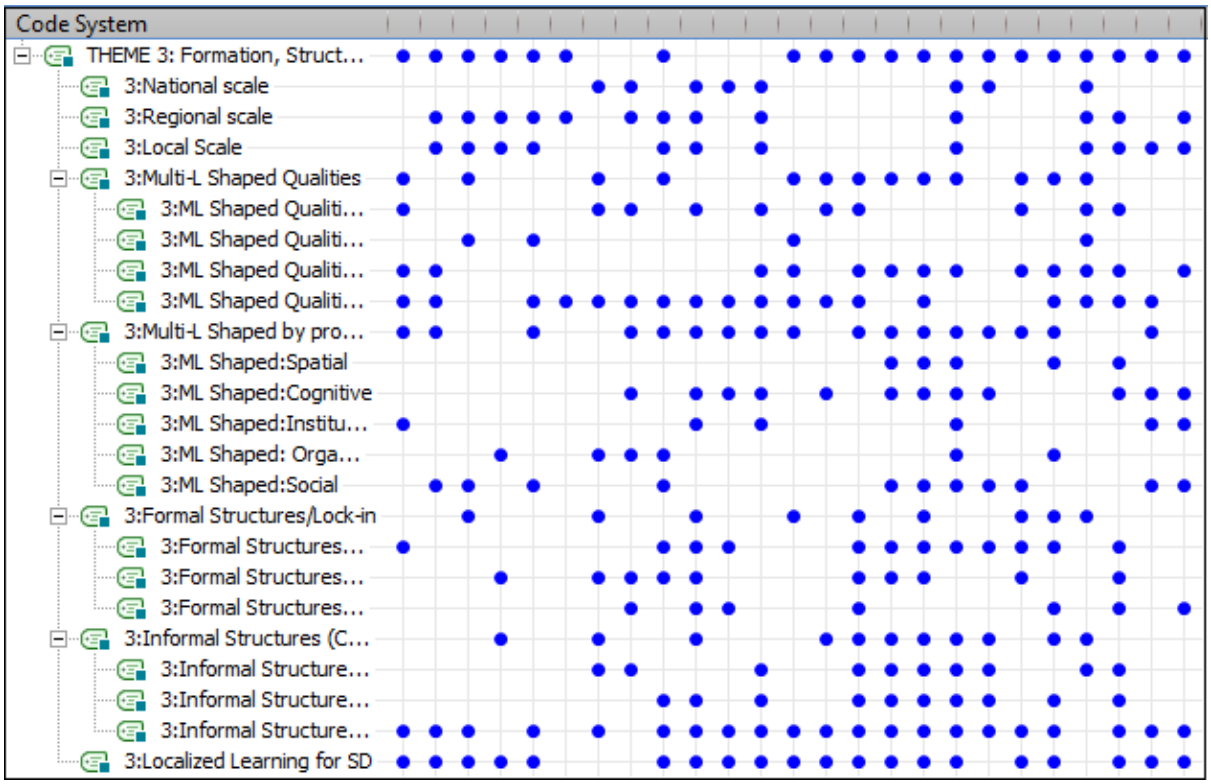


Figure D7b. Detailed breakdown of codes, and sub-codes versus the document texts

11.5 APPENDIX E: FOR PART III - W.C. Case

11.5.1 - Appendix (E1) – List of South African case anonymous respondents

W.C: Academics & Researchers	Respondents: A - B
W.C : Intermediaries & Civil Organizations	Respondents: C1,C2, – F
W.C: Private Sector	Respondents: G – L1,L2,L3, O - Q
W.C: RIS Level	Respondents: R - W

Table E1 List of South African case anonymous respondents

11.5.2 – Appendix (E2) - SA Theme I codes

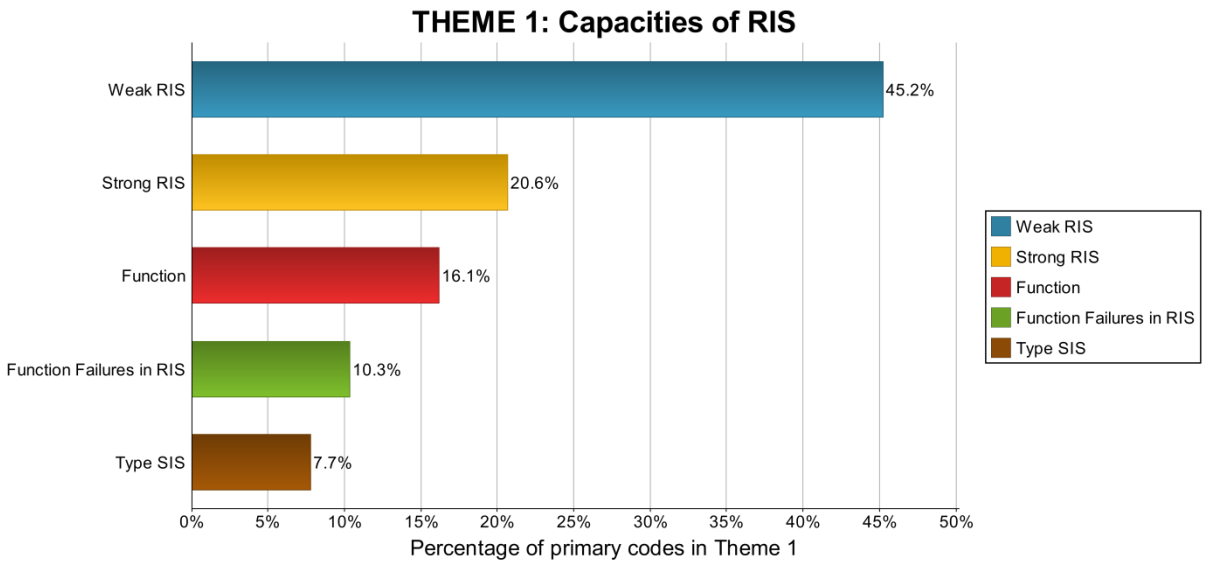


Figure E2. Theme 1: Capacities of RIS

11.5.3 - Appendix (E3) - SA CASE – Theme II codes

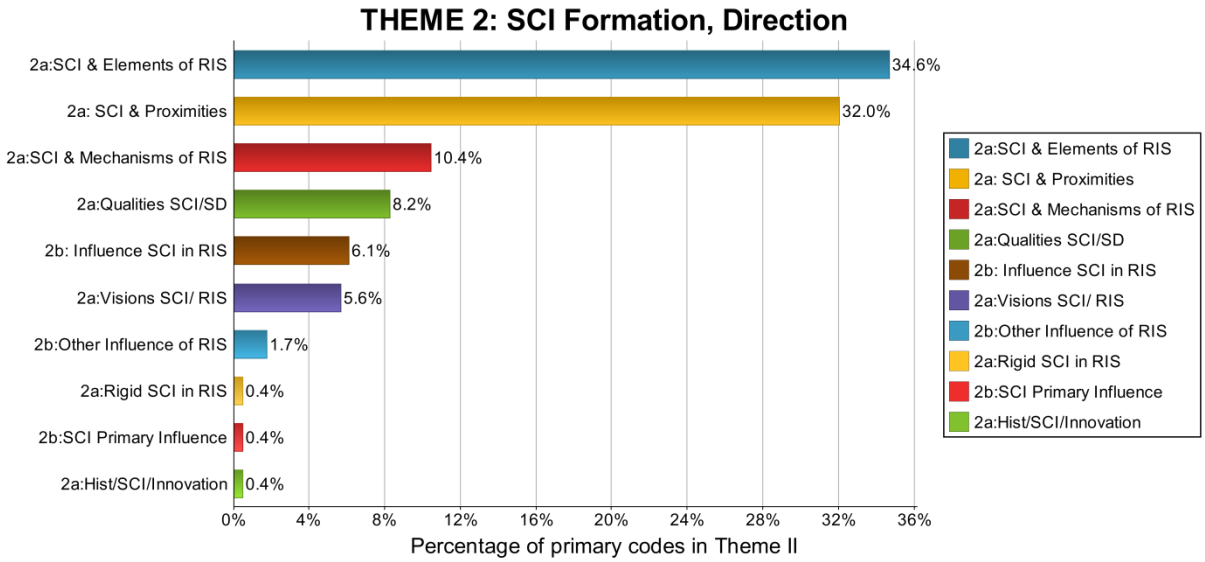


Figure E3. SA Case-Theme 2: Formation and direction

11.5.4 - Appendix (E4) - SA CASE – Theme III codes

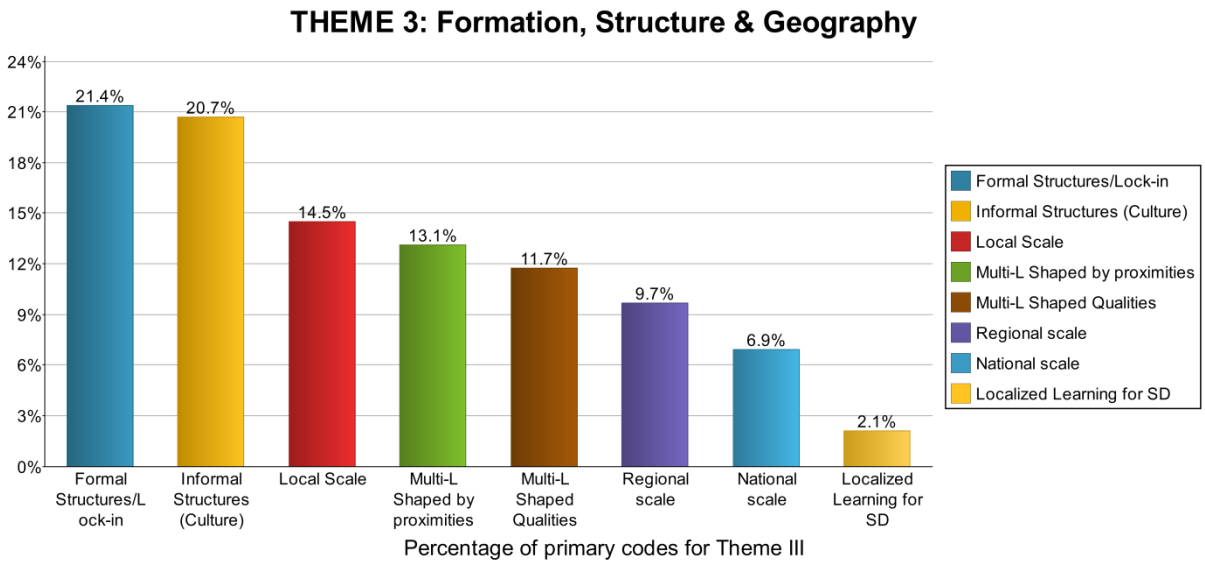


Figure E4. Theme 3: Formation, structure and geography

11.5.5 - Appendix (E5) – Transforming technopark vision and discussion documents

"To enable and create a Sustainable, vibrant and active Innovative Community"

Contents

1. Synopsis of Document and main Discussion Points

The document gives a brief background to Technopark in terms of its original design as a Science Park in the eighties. It also discusses how the park developed commercially and where its potential now lies in terms of a future mandate and development. The research is described as an intervention, to engage with stakeholders to assess the thinking around a future technopark. The document details the visioning and problem identification workshops. The various stakeholders included a wide diverse and mixed group of interested parties to more specific stakeholder groups. This includes the Technopark Owners Association Trustees, who separately established their own vision during a workshop. The challenge of the researcher is to bring the stakeholders together, as a facilitator and set in motion, discussion to find a joint and common strategic vision. Other main stakeholders include, the business community, the municipality, the university and InnovUS. The researcher has also commented on previous studies conducted by consultancies commissioned by the municipality.

A) Problem Identification: The problem is identified on multiple levels. The unit of analysis or the subject of research is Technopark. The problem can be identified as the following:

- *Lack of clear mandate of Technopark*
- *Lack of clear vision, leadership and stakeholder collaboration (in maintaining park as a 'science park' and in determining a future orientation for the park).*

B) Processes of problem-solving: Research as an intervention to facilitate process of inclusive problem solving together with stakeholders.

- *Gaining stakeholder perspectives at various levels*
- *Visioning workshops and action plans*
- *Joint problem-solving and action plan*
- *Forum discussions, meetings, interviews and facilitation*

C) Joint stakeholder-researcher envisioned outcomes:

- *Collective strategic vision and action plan.*
- *Transformation of Technopark toward 'sustainability orientated park' with 'innovation' mandate through collaboration.*
- *Collaboration in a formal sense with Municipality, Technopark Owners Assocation (as governing bodies [v]), businesses and the University (InnovUS).*
- *Possibility for a joint advisory group for Technopark consisting of representatives from each stakeholder group and possibly also GreenCape (PGWC).*

D) Joint proposal for funding/ venture capital

E) Possible establishment of joint Innovation and Research commons or facility in Technopark

2. Background Description

2.1 Introduction

Technopark was originally conceived of as a Science Park in the late 1970's when Prof Christo Viljoen, then vice-dean of the Engineering faculty at Stellenbosch University, went to Taiwan. There he visited Shinshu Science Park, one of the world's revered successes. He brought over the concept to Stellenbosch, and managed to obtain buy-in from the local and national government. The park was established in 1985, and was supported by the Industrial Development Corporation and housed an incubator and innovation lab. The park was managed by a committee and the local municipality. The entering of firms into the park was very slow for numerous reasons including a poor community understanding of the concept and benefit of a science park. Other external factors such as an economic slowdown forced the management to allow it to become market-oriented in the 1990's and the strict criteria of firms entering the park were relaxed. (For a United Nations definition of a science park go to http://www.unesco.org/new/en/natural-sciences/science-technology/university-industry-partnerships/science-technology-park-governance/concept-and-definition/).

Today the park is well developed, albeit not as a traditional science park, and consists of a variety of businesses ranging from satellite manufacturers, banks, financial institutions to the headquarters of a liquor company. However, there do remain numerous firms that fit the profile of traditional science park firms, but more importantly, fit the profile of the modern concept of 'innovation hubs'. There are a number of Internet & Communications Technology, (ICT) businesses and engineering firms, financing firms and others (*see www.technopark.co.za for a detailed breakdown and http://blogs.sun.ac.za/sisn/ for info*).

The more modern concept of 'innovation hubs' or 'innovation environments' allows for mixed use, living spaces and an interactive and attractive space for citizens. This ensures the sustainability of the use of space and enhances vibrant interaction and creativity through sharing of ideas at strategic meeting places. What all these 'innovation environments' have in common is a strong link to knowledge centres or universities providing incentives for collaboration and mutual learning. Furthermore, the concept of clustering similar industry together, as in the traditional model of a science park has been shown to have mixed results. The more modern concept also allows for looser boundaries and encourages numerous visitors to the park, which brings in new knowledge and diversity. The vibrancy of modern 'science cities' are known to stimulate innovation and mutual learning in all sectors (*see 22@Barcelona article*). This vibrancy is often created through incorporating arts and cultural elements into the environment. Universities benefit because they can align certain research projects with real world ventures, and collaborate for joint problem solving. Firms benefit because they receive a flow of new knowledge, information and expertise that increases their competitiveness and innovativeness. All benefit through various forms of joint training and education programmes or internships for students etc.

Furthermore, these science parks in the past were primarily designed for economic growth and regional competitiveness. Technopark, similarly has a very competitive business climate, where most of the business owners do not engage with each other and serve international clients. They have a lot of interest in sustainability but little knowledge of it. The hypothesis for the transformation of Technopark lies in its future design, as a Sustainability oriented Innovation hub or urban 'Innovironment for Sustainability'. Through the transformation of the physical infrastructure and the implementation of

sustainable systems (3R's, energy etc), the park is expected to attract businesses and investment which are Sustainability oriented, and want to be associated with the park. This is a well-positioned opportunity for the investment in capacity-building for sustainability for the region and the green cape initiative and sustainable Stellenbosch. (green-cape.co.za & www.sustainablestellenbosch.co.za).

2.2 The research Intervention

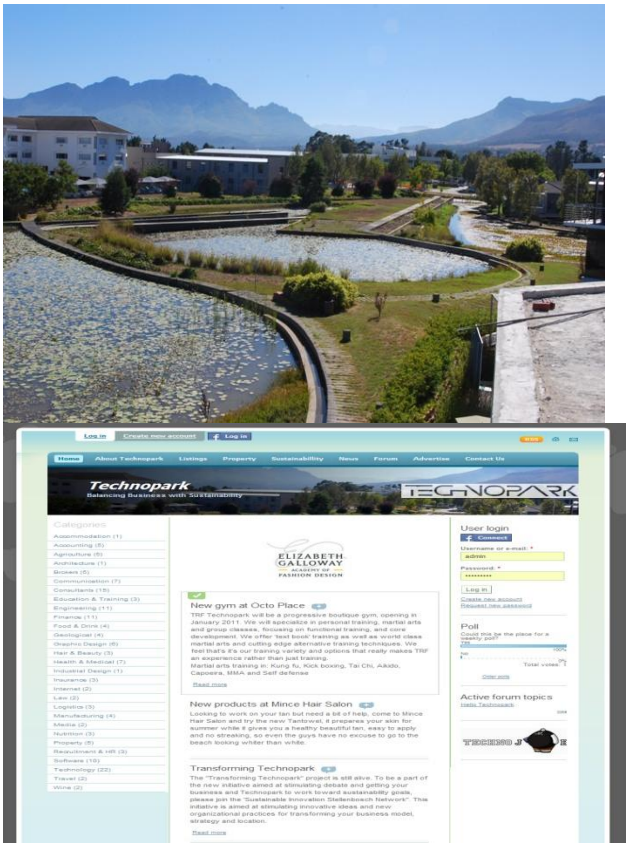
With the advent of the research intervention project there has been a lot of stimulation and talk about sustainability in Technopark among several stakeholders. The primary stakeholders are the Technopark Owners Association (TPOA) whom represent the owners of the buildings. They are legally bound by a constitution, and have to engage with the municipality on several matters of service delivery in the park. This relationship has been strained in the past, but with new visions for the park and through stakeholder engagement there is hope for much better collaboration in achieving i) a collective strategic vision and ii) implementing the vision.

In January 2010 a preliminary study including interviews and contact sessions with the Technopark community revealed that the mandate of the park was in a state of flux. What was worse was that the service delivery was very poor, and the park was neglected. The local municipality conducted several studies concerning this matter, however, there was no immediate improvement (*the findings of the most recent report are included*).

Through the research intervention, a public event was held in June 2010 designed to establish a future vision for the park, which was well attended. The vision was established by a wide group of stakeholders through a workshop – where the challenges were also raised (*This vision is also attached*). After the event, however, numerous individual concerns and fears arose that the reinstatement of the park as a conventional science park would be established, primarily by the business owners. There were several fears that the traditional 'science park' ideal would result in businesses having to leave the park as they did not fit the profile of a research and development or ICT company. Since then, and through the intervention of the research process, the stakeholders understood that they were in control of their own destiny and would not be dictated to by government or the university. Consequently their vision and the vision of the TPOA together with the municipal reports provide the road ahead for the future development and transformation of Technopark toward an innovation hub for sustainability. The official vision of the TPOA is, ***"To enable and create a Sustainable, vibrant and active Innovative Community"*** [By 2015].

3. Google Map of Technopark

3.2 Where is the heart of Technopark? What are the assets of TP? Official Website?



4. Transforming Technopark (Visions & Challenges)

4.1 Vision 1: Wide Stakeholder Vision 4th June 2010

WORKSHOP ON ESTABLISHING A COMMON VISION FOR TECHNOPARK

Clarity on an issue:

"We at Stellenbosch Academy have the intention of going totally off the grid within the next five years. But don't have the technological knowledge, and want to know where to access this. BARBARA FASSLER – Director Stellenbosch Academy."

Team members' Visions:

Overarching Question: 'Somebody is experiencing something in Technopark in 2015, what does the community look like?'

<u>GRP 1:</u> {Philosophy PhD; Strategic Performance Managers; WWF Peace Parks NGO; Regional Government; Branding & Marketing Distell} Green Routes, bicycle lanes within TP and connecting TP to the rest of Stellenbosch. Some form of public transport, or improvement of current transport. Walkways and public spaces for people to meet. Swap shop, Kindergarten (Play-School; After-school facilities). Open days, involving people from wider community (Khayamandi); Fashion show (Elizabeth Galloway; (Activities); Photographic exhibition; Scientists/ businessmen can give lectures; Village concept (Connected & Integrated community).

LAURIE – Somewhere where the TP community can interact. Q&A – None

<u>GRP 2:</u> {Engineers; Businessmen (Technical skills) Architects; Urban Designers; Academic} Market Place; Hub; Activities; Place to Exchange ideas inside & Outside Technopark (University; Kayamandi; Government)} Currently there is an experience of competitiveness between departments at the university; Rural Place – must retain rural feel; (Picturesque & Fresh air); Urban Agriculture; Lots of green space; Public space, to go for a walk after lunch; Place to sit next to a stream/dam or under a tree; Vegetables can be grown here, and are free to take; Erection of a state-of-the-Art Icon building; (Compared to Table Mountain – super attraction); Best & Fastest IT broadband and Telecommunications in the country; Off-Grid as far as possible (Utilizing renewable and Sustainable Technologies/Energy); TP must be less dense in terms of cars, and must be linked by green-routes to other parts of Stellenbosch; TP must not be an island but must be a centre or hub of activity; Must be linked by better modes of transport, green modes of transport; Must support & showcase green technologies;

<u>Q & A – Icon building</u> – Comment: Buildings not particularly env. Sound (From England) Icon Transformation of Existing buildings; Q: Get off the grid, HOW & WHAT? Just energy, or energy & water; *Reduced carbon footprint (Complete Carbon Footprint) Water, Energy, Waste, Lifestyle.* ***Transport – Regulation of electrical vehicles? (Traffic Regulations eg. Golf cart? Why not? Joule R235 000); R50 000 and travel 50 km/h.***

<u>GRP 3:</u> {Prof. Alan Brent (CRSES); Businessman (Solar Energy); Accountants; Human Resources & Industrial Psychologist; Energy Engineer (Energy Optimization); Mixit; Industrial Engineers} Started talking from the technological viewpoints about resource efficiency and then shifted completely to the social elements; The most important is the

human resources; What is needed to lure and attract the best human resources?; Social interaction for human resources; Effective logistics; People staying in TP or close by; Communication between people and businesses (Forum) or internet based chat facility for human interaction; technology that is required to make TP attractive for example recycling; Interaction with environment; What is the future TP design going to look like, incorporating the environment rather than impacting on the environment; make it attractive for people; Start with the human side, and the technology will be dragged along as a result of that. ***Q & A – None***

GRP 4: ***{Santam; EDH Engineer; GEOSS Geo-Hydrology Engineering; Eco-International, Sustainable Energies}*** Setting targets, water reduction; public targets, monitoring our resources use; Not have to leave Technopark, tranquil serene, future design element; special place; affordable housing in or near technopark; public transport in and out of technopark; what kind of companies do we want in technopark; What incentives will be put in place to lure investment and the best human skills and companies; How are we going to create a symbiotic environment; what spaces are we going to create for a symbiotic environment?; How are we going to invigorate existing companies to take up the vision or contribute to a constantly improving vision? How are we going to utilize existing companies in TP and combine skills, brain power and knowledge to reach these goals; Management – who is going to take responsibility of this initiative, who is going to drive this initiative and manage it? How is technopark going to be conscious? Conscious of surroundings, environment, people and who we include and exclude, its own functioning (Resource use and infrastructure) and identity.

GRP 5: {Stellenbosch Design Academy; Academics; Nedbank; Engineers; Water Saving Practitioners} There is knowledge out there, but not being utilized properly or optimized. Knowledge should be made available to through the correct channels so as to make use of it more effectively. This is knowledge about Sustainable Development and new technologies for sustainability. As well as the knowledge for changing mind-sets.

KEYWORDS

GRP 1: Leadership for Responsible Communication

GRP 2: Champion, "Buy-In", Social [Human Resources]; Socialize Government that buys-in

GRP 3: Rural Quality Environment; Connectivity & Demographic Diversity; Green Transport and Pre-competitive environment

GRP 4: Responsibility – Ability to respond; Symbiotic Relationships (Feeling part of the community); Meaning or commitment.

GRP 5: Etiquette (Educate); Conserve; Manage

SUMMARY OF REASONS FOR NOT DOING IT NOW (BLOCKAGES)

GRP 1: No money/finance; Scared to Try; (We have to dream, we don't believe and we think its impossible)

GRP 2: Passiveness (Passivity); Lack of Proper Leadership; Lack of passion (Distance between the heart and the head)

GRP 3: Lack of Common-Vision; Resources; Barriers (Knowledge, Economics)

GRP 4: Self Interest; Cost (Eg. Cost of converting existing infrastructure); Apathy

GRP 5: Lack of Governance; Lack of community mobilization; Lack of Knowledge; Lack of commitment to a shared vision. (No reason for not doing it now).

Laurie Barwell posed a final question, "Was this event useful? Did you enjoy it and should we organize the following event to be held after the world cup?" There was an overarching consensus of agreement to all these questions.

The event was convened, and special thanks were given to all the speakers and facilitators. Protea Hotel and Simonsig were thanked for supplying wine, the venue and snacks.

DRAFT COMMON VISION FOR TECHNOPARK BY 2015

The draft common vision was established through the following method. Several categories were identified stemming from the data gathered during the workshop. Not all of the information is written above, as these only represent the conclusions of each group discussion, and therefore additional information may be included into the draft vision. The vision will be written according to the following **S*M*A*R*T*** guidelines. **S** = Specific **M** = Measurable **A** = Achievable **R** = Reliable **T** = Time based.

The following table represents the suggested importance of the following elements. The components at the top were mentioned as more important, and those below as less important. However, their respective importance is also seen as forming part of a complex vision, with each part contributing to a whole.

Table E Suggested importance of the elements

Social Elements	Technical Elements	Ecological Elements	Economic Elements
• **Leadership & Management** Champion(s), Visionaries, Catalyst, Discipline, Social Mobilization	• **Design** [TP infrastructure design, spatial, technological = focus on sustainability & excellence]	• **Resource Flows, Decoupling** [Design, adopt and utilize best technologies for reducing total carbon footprint; ecological sustainability]	• **Regional Economic Benefits** [Brain Gain, Job Creation, Marketing, Business & Industry Support]
• **Social Innovation**	• **Technological Innovation**	• **Educate/Social Learning**	• **Driver of Growth**
• **Human Resources** [Skills & Knowledge base]	• **Infrastructure & Resource flows** [Best infrastructure, ICT, Transport, support systems, public spaces amenities, living space]	• **Local Organic Food Production** [Urban Agriculture]	• **Business sense** [Innovation, symbiotic partnerships & mutual learning, knowledge sharing]

• **Community Cohesion** [Networking; Integration; Interaction, Socializing, Identity]	• **Clean & Sustainable Technologies** [Showcase; Implement, Design & Develop]	• **Revitalization of Ecology** [Parks, Dams Rivers, Ecological Biodiversity]	• **Economic Inclusion** [Skills development learning, Economic resilience]
• **Social & Institutional Inclusion** [Partnerships, collaboration]	• **Incubator, Innovation hub, Discovery-Innovation Institute**	• **Learning Centre/Hub** [A place/ space for learning about ecology/ environment]	• **Economic Linkages & Incubator** [Commercialize ideas, Innovate, Research]

SUMMATION of DRAFT VISION TP 2015 (4th June 2010)

The "Technopark 2015 vision" is based upon several opinions and a workshop held on the 4th of June 2010 for the establishment of such a vision.

By 2015, TP seeks to become a national and regional asset for Sustainable Growth. Technopark will provide the capacity to spearhead the regional GreenCape clean-tech initiative as well as provide impetus and support for the national Green Economy. This will be achieved through social, technological, ecological and economic directives to be achieved by 2015 in Technopark.

TP seeks a solid management structure that shall oversee and drive the project through a champion of change. This management structure will ensure that the goals and vision of TP are met within time. They shall provide leadership and facilitate partnerships with the university and government. TP will provide spaces for community interaction, knowledge and idea sharing for business and beyond. TP will be connected to the rest of Stellenbosch via green routes, supporting sustainable public transport. Most importantly by 2015, TP will

provide and house a state-of-the-art facility for social learning, idea and business incubation and a discovery-innovation centre for national problem solving and idea generation in line with the principles of sustainable development, the national Green Economy strategy and National Research directives. It will be a neutral space for beneficial collaboration between research institutions, government agencies, business and industry.

TP seeks to become the first example of a future sustainable urban node in Africa, where people interact, and children play in a safe picturesque environment. Bicycle lanes are provided and public transport is readily available to connect to wider regions including Cape Town. TP seeks to become its own innovative solution, placing emphasis on human health and workplace wellbeing – certain areas shall support organic agriculture and other public activities – and people will be free to harvest their own vegetables. The rural feel of TP will attract the best artisans and skilled professionals for the benefit of businesses in TP. It will become a market place for innovation, creativity and productivity.

TP will be able to showcase the best sustainable technologies, and most of TP will be self-sufficient in terms of energy usage. Water usage will be minimized through extensive reduction in consumption and re-use through sustainable technologies. Similarly the principles of waste minimization, re-use and recycling will be applied creating skills and jobs in the interim. All new buildings will be mandated to be green buildings. TP will harbor the best infrastructure in terms of telecommunications and network infrastructure while subsidized by government. Tenants from TP will be able to access university networks and knowledge databases.

Finally, TP will have a common identity as a community of practice able to achieve the dreams of young South African entrepreneurs through a network of support systems. TP will drive regional growth in a sustainable fashion and serve as a centre of learning for sustainability and future living together with the Stellenbosch University (and other learning institutions) as well as government. The community of Technopark will provide a beacon for investment in African talent and will be able to teach other South African towns and cities how to transform toward a more sustainable and integrated South Africa.

4.2 Commentary on Revised vision at the Sustainable Innovation Stellenbosch Network Forum

PROPOSED GUIDELINES FOR TPOA

***[FORUM RESPONSES 16th March 2011]**

-SUSTAINABILITY & TRANSFORMATION SUB-COMMITTEE-

Action Plans According to Strategic Vision for Transforming Technopark

Strategic Proposed Vision (RECOMMENDATIONS AMMENDMENT 1):

Technopark seeks to Transform into a Sustainable Innovation Hub by 2015 as the official mandate. All activities in Technopark should aim to be sustainability-oriented. This includes transformation at three levels **1)** The Greening and Sustainable Development of Technopark. **2)** The Mandate of Technopark as a Sustainability Innovation Hub (Ratified by a constitution and accommodated by rezoning adjustments). **3)** TP collaboration is spelt out via a transparent and mutually beneficial Mode of Agreement established with the University of Stellenbosch [v](CHEC) **Cape Higher Education Consortium**, local and provincial Government of the Western Cape.

[Each of these aims, are sub-divided into action points for achieving these aims and ultimately the vision they collectively support].

The purpose of this vision is to manifest Technopark into a vibrant sustainable innovation community and cultural hub, providing knowledge and expertise for sustainable futures, **locally, nationally and globally. Technopark seeks to compete on a world stage as a novel concept for fostering sustainable development.** It is an inclusive vision that seeks the contribution of all Technoparkers as well as the Stellenbosch academic, business and governance ***(or government)*** structures. The future leadership and decision-making of Technopark is represented by a Technopark Leadership Council ***(or committee/team)*** (TPLC) which includes representatives from academia and the municipality **into the existing TPOA.** The management of TP may be outsourced by a professional full-time manager or company that serves to maintain the interests of the (TPLC) and Technoparkers.

TP should **boast** a state-of-the-art facility for research, **idea labs**, **incubators, design** and innovation commons (hub). **Its purpose is aimed at catalyzing and enhancing**

sustainability competitiveness in businesses, and in enhancing technological and process innovations for socio-economic and sustainable development.

[DELETED] the business tenants of Technopark and Stellenbosch – so as to improve the competitiveness of businesses in Technopark and attract businesses in the sustainability technology and services industry, whilst retaining a mixed-use environment. Ultimately TP should become a vibrant and modern urban space with an ability to attract and showcase technology and social organization for sustainability in South Africa. Above all Technopark should strive to increase its productivity as a future urban space.

INCLUSION OF 'SHORT VERSION' VISION/MISSION STATMENT:

The vision of Technopark is to become an interactive and vibrant learning, innovation and knowledge collaboration environment for technical, social and environmental sustainability excellence.

Comments and Amendments to Above – Names & Contacts (optional but preferred):

SISN FORUM HELD 16th MARCH AT BLAAUWKLIPPEN (COMMENTS BELOW) THESE ARE SUMMARIES OF GROUP INTERACTIONS AND COMMENTS. ALL ANSWERS ARE KEPT ANONYMOUS.

*** What, who and how? Need experts!!**

*** Transform public open space into community areas; parks; outdoor gym.**

*** Leadership – Must have Owners Buy-in.**

*** Must make sustainability fashionable in TP.**

*** Use water to heat and cool.**

*** Open air theatre.**

*** Need shorter vision / mission (simplify) 2 sentences**

*** Based on workshop forum of stakeholders. Need to create climate of true collaboration & mutual respect –clever people tend to be competitive. Vision too long and complex – summarize – need one liner sexy title – one liner than can inspire (mission).**

*** Need incentives to encourage people to go greener and live less resource-intensive lives/lifestyles.**

*** The vision looks good, problems might be in the implementation and getting the buy-in of all the stakeholders (companies; residents; etc).**

*** Solutions include attaching incentives to being 'green'.**

*** Residential commercial zoning; retail?**

*** Sustainable Gardening; Each company sponsors a garden (areas for development – public open space/ common property). Divided responsibility. Sense of ownership in Technopark. Community vibe & Pride.**

Three overarching goals contained in the vision:

These goals are connected and in a sense necessary components for achieving a collective, sustainable and holistic vision for the future of Technopark.

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1) The Greening and Sustainable Development of Technopark

2) The Vision, Mandate & Zoning of Technopark (Includes Management & Governance of TP)

3) The Collaborative Framework:

In Agreement or Not in Agreement? Please give reasons and further suggestions below. What problems do you foresee? EVERYBODY AGREED WITH THE VISION'S THREE COMPONENTS ABOVE; ADDITIONAL COMMENTS INCLUDED:
***Greening and Sustainability is a positive feature.**
***Elaborate on Zoning, needs extra discussion and debate.**
***Too academic**
***Agree with overarching goals**
***Start social events, projects that will include all in TP, and that will be a platform for knowledge exchange and this should help in achieving and implementing the collective sustainable vision for TP.**
***Give feedback of developments to all [website] this should also help to get buy-in.**
***In agreement with project: Incentives at work to encourage employees and owners to go greener and live less resource intensive lifestyles. Incentives, eg. biking to work. Competitions, fun days.**
***Provide pedestrian and bicycle lanes**
***Green: attract companies that work in environmental and sustainability field**
-attractive environment; example of low resource user/s (TPark).
-collaborate with the Sustainability Institute [and Centre for Renewable and Sustainable Energy Studies CRSES].
-Water recycling systems (greywater systems); Roof gardens
-Creativity (Spaces)
-Create a space people want to come to, is attractive for clients; track changes on website.
-create inviting suggestions.
Green makes place attractive in all ways (retrofitting buildings);
Social responsibility economics
Make it pretty (attractive).
***Zoning: Change zoning by amendment**
***Collaboration: Include CHEC and other universities.**
***Technical, legal and political change (mandate)**
***Need ownership agreements; inputs from all stakeholders; needs to be ongoing – so TPOA (TP Leadership Council needs to energize; TP Sustainable Development Team / association**
1) TP should be an example/ showcase to attract sustainability focused organizations. Goals should be sequential: Greening; Social; Economic
2) Start with Point 2 as First Objective.
3) Could help to enhance aims into objectives that are SMART: (S)*specific (M)*measureable (A)* achievable (R)* relevant (T)*time-based.
***Indigenous trees and vegetation**
***Bicycle lanes in TP, and bike storage facilities**

***Need a well-represented committee in TP that can make high level decisions and liaise with government and the university**
***Improved utilization of public space; commons**
***Need to develop strategies for continually adding value to TP.**

Achieving the Vision and Transformation: Action Points

1: Greening & Development:

- Ecological Assessment of Technopark (Dams, Wetlands, Grassy Areas, Fynbos, Potentials, Roof Gardens etc.
- Infrastructure (ICT, roads, parking, security, etc.)
- Agricultural spaces / Food Gardens
- Recreational Spaces
- Recycling
- Transport / Traffic / Parking Solutions
- Safety & Security
- Energy Audit
- Water

Please provide additional points below and make suggestions and comments:

*Tram line link to Stellenbosch Town Centre and University
*10-20% Residential
*Neotel or Broadband link to TP and university network; improved cable infrastructure
*Trust fund or funding scheme for realization of projects
*Owners & business levy (Central improvement District levy) like Cape Town
*Use Cape Town partnerships model for upliftment of infrastructure and re-development of TP
*Pilot projects, small commencement projects
*Government funding project; Energy projects
*Solar park; off the grid and independent of Eskom
*build TP image as Sustainability centre
*Public transport; dedicated bus service; improved taxi shuttles
*Continuous workshops for Sustainability; learning and education centre
*Alternative entrance/ exit for Technopark
*Expansion and greater zoning area for Technopark
*Idea of a soft boundary; extend boundary to include Stellenbosch town (infrastructure and networks for sustainability)
*Picnic areas; benches; fishing facilities for dams; walkways
*Education through bio-diversity gardens; fynbos gardens; greenhouses

*Dedicated evening security; sign in
*Group pledging: X needs this amount = if all give x then we get amount Y.
*Different funding options for the realization of the green projects need to be explored.
*Need to bring in and lure experts.
*Get companies to help, and sponsor certain greening projects (such as the dams).

2: Vision, Mandate, Constitution, Zoning & Governance / Leadership / Management:

- Establish & Finalize vision (Display for Public Comment)
- Ratify Final Vision
- Establish Mandate / Amend Constitution of TP (Must be Sustainability-Orientated)
- Establish transparent code of conduct, mission statement, rules and regulations of the TPOA (TP Leadership council/committee)
- Reinforcing the TPOA to include (Academic Representatives, Business Reps and Municipality/government)
- Establish Expert TP Manager and Management (Clear Goals, Objectives & Deliverables)
- Finalize Zoning Adjustment as (Sustainability Innovation Park / Hub) [Meaning all future businesses with Sustainability interest get preference to entry]
- TP Trust Fund / International Funding / Governmental Support Fund etc.
- TP Communication Channel / Platform (Develop and support www.technopark.co.za).

Please provide additional points below and make suggestions and comments:

*Need to formalize partnerships and collaboration with municipality and government

*Need to bring in expert, or use proper research which is busy being conducted by PhD project to establish working vision, and include stakeholder viewpoints

*Continued workshops and forum meetings to convey messages

*Stimulate social learning processes, and provide experts on sustainability for businesses

*Need competent management of TP

*Education and learning in TP is needed

*Needs to be a monitoring and evaluation of our activities, and businesses

*Need to help businesses adopt sustainability in their functioning; CSR and social projects

*Sustainability will only work if we compromise our comfort now for future

*Code of conduct and rules: start with proposal and get buy-in same as doing now with vision
*Tax exemptions; government incentives
*Need MOU for Mutual collaboration (Govt-University and business).
*Less talk; more DO; can achieve
*Must rezone after vision is accepted
*Networking and collaboration is beneficial to all

3: Mode of Agreement / Understanding, Networking & Collaboration for Sustainability:

- Proposal for Mode of Agreement / Understanding
- Establish Contract with University / Municipality / National & Provincial Govt.
- Funding & Tax exemptions etc
- Future potentials for online network in Stellenbosch: The Sustainable Innovation Stellenbosch Network (SISN)
- Continuation of Forums, Networking and Collaboration
- Knowledge Cluster; Knowledge Production/ outputs; Co-production of Knowledge; Idea Labs and Business Incubators (University-business-Govt relations)
- Sustainability and Society: Solution oriented Focus for Stellenbosch
- HOPE Project??

How do we initiate and sustain the above 'social capital'? Comments and suggestions below:

*Business incubator
*Communication platform
*Continuation of Forum; discussion groups
*Involve key stakeholders; personalities and champions for the projects
*TP Open day; TP events; Regular social engagements; Exclusive parties or cocktails events
*Get people from government involved
*International AID funding
*Need venues or a place where people can meet
*Needs to be a core or central office for Technopark; Management office; Research commons
*Art and culture centre
*Network and exchange ideas with partners; continuous basis
*Marketing for networking and collaboration; showcase results; learning centre
*SISN Forum; share ideas; give businesses a chance to talk; get more involved
*Agree to use university resources; link to HOPE Project!

*Get high profile people together; chancellors; Johan Rupert; Big Business representatives
*Get endorsements of project; WWF; Remgro etc.
*Improve online communication and platform

4.3 A second visioning workshop was held exclusively for the TPOA trustees

A visioning workshop was held with the Technopark Owners Association on the 2nd May. A similar process was used to systematically arrive at a strategic vision. The report of the meeting/workshop is available upon request.

The final outcome of the 3 hour workshop was the following vision:

'To enable and create a Sustainable, vibrant and active Innovative Community'

As well as agreement on the following process to be followed in the next two months

1) To meet with the Municipality and gain their stakeholder perspective on TP.

2) To converge ideas into a discussion document.

3) To discuss the Transforming Technopark project with the University (formally).

4) To discuss a strategic collective vision and action points, with all stakeholders present, at a workshop in June/ July.

5) To establish a formal Memorandum of Understanding between the University, the TPOA, and the Municipality.

5. Municipality Drafted Consultancy Report, 2009 – Key Findings

[COMMENTS FROM RESEARCHER'S ETHNOGRAPHIC PERSPECTIVE]

5. Opportunities and Challenges

5.1 Opportunities

- Stellenbosch University provides a skilled pool of graduates to the Technopark.
- Located close to institutions such as the CSIR, Stellenbosch University, Elsenberg Agricultural College and Sustainable Energy Institute.

- Easily accessible.
- Located in a rural ambience.
- Located in the Western Cape which is one of the major tourist destinations in South Africa. Thus, there is a marketing opportunity to attract major players in the areas of science and technology.

  [As spelled out in the various workshops, there are far more benefits and opportunities for TP, than those that are mentioned here. It is all about opening up the debate to all stakeholders that more novel ideas and ownership of the project comes about. There should not be a top-down decision making without adequate stakeholder engagement. Various ideas and visions should be considered].

5.2 Challenges

- The economic meltdown is affecting all sectors of the economy.
- Parking is a serious problem because the green space is currently used as a parking area.
- Public Open Spaces are neglected.
- Most of the businesses do not comply with the scheme's parking requirements of one bay for every 30 m².
- Need for security enhancement.
- Need for partnership between the Municipality and Technopark Association.
- The two-storey height restriction is causing delay to development. It is recommended that three storeys with the 11 m height should be applicable.

  [The challenges mentioned above are important, and <u>are</u> issues in TP. However they are superficial and minor challenges. The real challenges are to engage the community of Technopark in a collaborative and social learning process for Sustainability. This also means economic sustainability. To lure talent and expertise to the area and ensure continued investment into the park, via enhancing the use of space, and improving its attractiveness to big business. This means infrastructure improvement at various levels; for sustainability and technological enablement; research and development. This should be explored in

the workshop. Ie. What changes to TP will make it more profitable, sustainable and attractive, what will be the spill-over effects].

6. Evaluating Stellenbosch Technopark (Municipal Report)

Evaluation of technoparks is not an easy task. The fundamental limitation arises from the diversity of park characteristics. As noted earlier in the report, there is no commonly used definition of a technopark. Therefore comparing one technopark with another is quite a complex task. Professor Link citing Michael I. Luger and Harvey A in "Understanding Research , Science and Technology Parks : Global Practice : Report of a Symposium 2009 notes that " one of the conceptual difficulties is that there is no consensus about the definition of success. The most cited goals relate to economic development. However, both the literature and our data from interviews with park developers, elected officials, university administrators, business leaders and others confirm the existence of other goals , including technology transfer, land development, and enhancement of the research opportunities and capacities of affiliated universities".

Also noted in literature as one of the limitations is the absence of a systematic framework to understand the dynamic interactions amongst stakeholders.

[The US researchers work represents a systematic framework of stakeholder engagement, as science with society, and collective problem solving]

According to Luger and Goldestein, there are several metrics that can be used to gauge the relative success of a research park. Box B summarises the metrics.

Box B: Summary of the Evaluation Metrics

- **Meeting the goals of legislation**. One plausible way to measure the success of research parks is to assess their performance against stated **goals.**
- **Return on public investments.** Direct expenditure by government on land acquisition, infrastructure development, financial inducements, and the cost of land for research park versus other types of uses.
- **Enhanced firm performance.** This can be measured in terms of the change in income and cooperate tax collected by local, state, and federal government as the result of the growth of successful businesses inside and outside the park as well as the net gains in jobs.
- **Enhanced university performance.** Spillovers to the economy usually take the form of creation of codified knowledge, which can also be examined in other ways. Tenant often form research joint ventures with other firms in the park, and this can be tracked. Tenant companies may also provide benefits to the host university by sponsoring laboratories, professorship and, hiring students, or associating themselves with co-patenting activity.
- **Value of the park to tenants.** Another kind of measure is the value of the park to the tenant companies that benefit from the richness of the flow of knowledge between them and the universities. For example, the firms may seek the cachet of working in a successful park which can benefit the host university, tenant firms, and the local community.

Source : Understanding Research , Science and Technology Parks : Global Best Practice: Report of a Symposium:2009

7. Comparing the Stellenbosch Technopark with Best Practices

Global best Practice	Performance by Stellenbosch Park 2000-2008
Business model draws on best practices in the context of local conditions.	• Options vary in terms of whether the residents are owners or tenants. Leases do vary. • No specifications i.t.o. leadership development and attraction of postgraduate students. • [**Lack of understanding of opportunities for TP**]
Physical infrastructure stimulates social interaction and innovation with a cross fertilisation of ideas, flow of knowledge and technology and sharing of exploits and experience.	• Infrastructure designed to stimulate collaboration, interaction and networking. **[Disagree completely, no evidence of this!]** • Close to world–class Universities and research institutions (i.e. the Stellenbosch University, CSIR, The Sustainable Energy Institute and Elsenberg Agriculture College). • **No common area, research facility, innovation lab/hub, conference facilities, incubator, ICT support**

Cluster environment for knowledge workers that accommodates new business, education and research needs.	• Cluster in terms various business but not specific to technopark specifications. Presence of various businesses that have nothing to do with research and knowledge. [**This is total speculation. There is certainly knowledge creation and research in TP. The mixed use environment may in fact be more beneficial to stimulate new ideas and innovations. There is a need for creating infrastructure for engagement, collaboration and incentives for investment in an industry focus. Not forced!]**
Enabling environment to stimulate the impact of innovation into the region.	• The current environment needs improvement so that the local brand can be recognised locally and regionally to attract investors. **[True, but what is the local brand? What should it be, and who decides? It should be a collective strategic visioning process, as is supported by numerous successes in Europe. The more recent literature about innovation regions, learning regions and transitions & Sustainability, triple-helix and Innovation Systems].**

8. Conclusion of consultancy ordered by Municipality

Firstly, land ownership of any science park should preferably be in single ownership by an institution that is not profit driven, preferably a University or other research driven institution. Science based or research based institutions such as universities or teaching hospitals form the main anchor of most science parks. Secondly, successful science parks have a clear strategic vision that informs all the institutional arrangements of the park including financial models, marketing, tenant selection and networking, both within the park and with other outside institutions and stakeholders. Thirdly, a supportive and flexible policy and regulatory environment (for example development parameters determined by site development plans as opposed to zoning scheme) is critical in responding to the ever changing operational regime of technology and innovation led enterprises. Fourthly, effective and sustainable intra and inter networks based on shared and common vision of developing and supporting business development. Finally, flexibility of infrastructure, physical space as well as communication networks to accommodate the changing needs of technology and innovation driven enterprises.

The findings on the study of the Technopark shows that most of these attributes are not present in the case of Technopark and that, where any of the above attributes appear to be present, they are either not sufficient and or appear not to be there as a result of a strategically driven initiative aimed at realizing the benefits of a science park.

Nonetheless, given the proximity of the Technopark to some of the leading universities in the country and in the world, it is possible to develop synergies between universities and knowledge based enterprises with support of all the three spheres of government, despite the absence of the attributes of some of the successful science parks. In particular, the environmentally sensitive functional region within which the Technopark is located presents a perfect opportunity for research based organizations such as the (CSIR), the University of Stellenbosch and local Municipality to collaborate on initiatives aimed at promoting sustainable and liveable environments, with specific focus on building materials, methods and techniques, sustainable and alternative farming techniques as well as "green communities". The pivotal role of the wine industry on the regional economy should be visible in the research and development initiatives that should form the backbone of enterprises locating in Technopark. In other words, the Technopark should reflect the drivers of the regional economy in which it is located.

9. Recommendations of Consultancy Report

Whilst some of the critical and success defining factors of Technoparks and or Science Parks that have seen the relative success of the science park initiatives overseas are not necessarily present in the case of Technopark, it will be short-sighted to treat Technopark as an ordinary office park.

- The future development strategy of Technopark should be informed by the strategic location of Technopark in the regional economic space as well as the unique competitive advantage that Stellenbosch offers.
- Whilst the Technopark is situated in a unique and breathtaking physical landscape, it should be acknowledged that a beautiful physical landscape is not on its own sufficient to make it desirable for knowledge based and business development enterprises to locate in the Technopark.
- Sustainability should form the main pillars of all developments in Technopark, with emphasis on creating a "green park" with "green buildings" being the norm, especially where new development rights are sought as well as incentivizing existing buildings and infrastructure.

- Enterprises that are not knowledge/research based or oriented towards business development should not be encouraged to locate in the Technopark.
- The current development parameters together with basket of land use rights need to be revised during the Integrated Zoning Scheme process and existing enterprises that fall outside the scope of a Technopark should be allowed as non-conforming uses. In addition, the required parking rate of 1 bay per 30m² should be increased to be in line with the office park.
- Introduction of residential buildings in the Technopark should be resisted as this will result in demand for associated social infrastructure such as schools, clinics, shops, sporting facilities and places of worship that will eventually transform the Technopark into ordinary suburbia.
- Whilst the direct and indirect benefits of a Technopark are not yet quantified, it is strongly recommended that such an exercise be done as any initiatives that may seek to cross subsidize the enterprises locating in the Technopark, must at the minimum be supported by quantifiable benefits of the Technopark to the local and possibly regional economy.
- Where possible, initiatives that will lead to the maximization of the competitive advantages of the Technopark as well as strengthening its relationship with research institutions as well as the Universities must be pursued.
- The institutional arrangements that will see the Technopark Property Owners Association playing a far greater role in initiatives that will attract the "right" type of enterprises should be supported at all the three spheres of government. (involvement in ASGISA, JIPSA etc).
- Enterprises that are research based and/or those that provide "starter packs" for emerging high tech companies should be incentivized to locate in the Technopark, taking into account the resultant benefits from such enterprises to the regional and national entrepreneurial capital. The nature, duration and type of such incentives should be informed by further research with a specific focus on the locational prerequisites for such enterprises that are geared at business development as well as knowledge based enterprises and may also include a trade-off between development rights against a "sustainability suite".
- Further studies are needed to determine the possible strategic interventions that are required to attract the knowledge and business development based enterprises. The management of open spaces, security as well as interventions that will lead to an optimal management of vehicular traffic entering and leaving Technopark will be critical in creating an environment with a competitive advantage to draw hi-tech and knowledge based enterprises.
- The provision of off-site park and ride facilities should be explored jointly by the Technopark Property Owners Association and the other stakeholders. In addition, due to the fact that the required 1 bay per 30m² was not always enforced and the result is that there is insufficient parking in Stellenbosch, Council should encourage private enterprise to develop parking areas on Municipal property.

10. Challenges from the Researcher's Perspective

General challenges

- **Initially lack of coherent understanding of Sustainability in Technopark (Learning has been achieved through stakeholder engagement, website etc. Long way to go).**
- **No sense of community in Technopark**
- **People did not/do not see a reason for the transformation of Technopark**
- **Short-term understanding of problems (Understanding of problem as day-to-day issues; no long term vision!)**
- **There is a need for bolstering leadership capacity and management in Technopark**
- **Lack of collaboration between the businesses (most probably because of lack of attractive open-public spaces, no social life, no bars etc.)**
- **Tension between TPOA and Municipality i.t.o service delivery. (Communication barriers – research project has served as an intervention, and communication between stakeholders is taking place slowly).**

Challenges regarding the Greening and Eco-design of Technopark (Only suggested challenges there are certainly many more).

- **Traffic flows, parking & mobility (Municipality put in traffic circles – more problems!)**
- **No green spaces; parks; recreational areas; cafes; lunch-time areas; beautification**
- **No adequate recycling; waste (Future project for Stellenbosch Academy of Design)**
- **Energy supply problems, energy efficiency? Street Lighting etc.**
- **Water flow problems; irrigation; dams in bad state; pump for irrigation and dam flow is broken; Water drainage; flooding issues**
- **No green buildings, but great interest!**
- **Bird reflectors/ right next to dam; no bird life!**
- **Potential for buying energy from solar power project at Spier (Buy-in challenge?)**
- **Waste water?**
- **Many more.**

Challenges regarding the collaboration framework and mandate of Technopark & Transformation process

- **No synergy and collaboration between stakeholders (is changing, and there is potential)**

- **Needs to be an agreed upon strategic and collective vision for the future of TP**
- **Needs to be a 'champion' of changes (Can be an organization, or institution, or one person)**
- **Need of representative decision-making body (TPOA, business representation, Municipality,**
- **Veto powers need to remain in hands of owners for sense of ownership**
- **Need for university-TPOA/business-municipality collaboration**
- **Need for experts**
- **Need for a focus for the park (ie. Innovation Hub for Sustainability)**
- **Name change – new identity (ie. 22@Barcelona; FutureBosch; Sustainable Innovation Hub Stellenbosch etc etc.)**
- **Soft elements; Network building (Continuation of online platform, forums, engagement spaces ie. Sustainable Innovation Stellenbosch Network).**
- **MOU agreement; HOPE Project affiliation**
- **INNOVUS (Technology transfer)**
- **INFRASTRUCTURE & MANAGMENT**
- **Include big business players, involve all of Stellenbosch (Remgro; Steinhoff; BAT)**
- **Official professional proposal**
- **Needs financial backing and investment (National Government, COFISA, UN, Aid)**