A competency profile for technology innovation leaders in knowledge-intensive organisations in South Africa

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Declaration

By submitting this dissertation electronically, I, Abraham Vlok, declare that the entirety of the work contained therein is my own, original work, that I am the sole author thereof (save to the extent explicitly otherwise stated), that reproduction and publication thereof by Stellenbosch University will not infringe any third-party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

A. Vlok December 2017

Abstract

The innovation economy is inextricably linked to advancements in science and technology that create new opportunities for innovation, as well as unprecedented leadership challenges for those leading teams from new scientific knowledge to successful technology innovation. Scholarly contributions to the innovation knowledge base have increased exponentially in recent years with little evidence of aggregation or integration of insights across theoretical foundations and disciplines to benefit technology innovation leaders. Most institutional leaders surveyed regard innovation as a priority, yet do not know how to improve their innovation performance, or which leader competences are associated with successful technology innovation.

This explorative study into the competencies of successful technology innovation leaders from different disciplines, institutions and technology domains has led to the observation that linear sequential predetermined innovation process models that worked in the industrial age may not be appropriate for leading technology innovation in the innovation economy. This mixed-methods study identified technology innovation leader competencies that are deemed to be required for successful technology innovation in a competency profile based on the observed empirical results. During a qualitative first research phase, expert opinions were obtained through personal interviews and triangulated with workshop findings, case materials, and published materials in order to define interim capability clusters across innovation processes, which were used to develop a self-administered questionnaire as measurement instrument.

A pilot survey with a sample of technology innovation leaders confirmed interim capability clusters as constructs and behavioural items for testing in the main survey. Peer-based snowball sampling through personal networks and professional associations resulted in 266 survey responses to provide research data that was processed into descriptive and inferential statistics meeting threshold parameters. A hypothesised model reflected relationships between the success orientation of the leader, the integrative competencies of the leader and competencies related to technology connectedness, stakeholder alignment, liberating mindsets, value creation and value realisation.

Reflective partial least squares structural equation modelling was used to derive a statistically-grounded model after evaluation of the measurement model and analysis of the survey results by utilising the bootstrapping functionalities of SmartPLS. Rather than commenting on the merits of existing theoretical frameworks, this study revealed the significance for the technology innovation leader to be competent at different competency clusters that may not conform to existing paradigms of established disciplines and their core assumptions.

Key words: technology; innovation leader competencies; integrative leadership

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List of acronyms and abbreviations

AACSB	Association to Advance Collegiate Schools of Business
ANOVA	analysis of variance
AVE	average variance extracted
BRICS	Brazil, Russia, India, China and South Africa
CEO	chief executive officer
CSIR	Council for Scientific and Industrial Research
DA	discourse analysis
DST	Department of Science and Technology
DTI	Department of Trade and Industry
EQ	emotional intelligence
FTE	Full-time equivalents
GDP	gross domestic product
GE	General Electric Company
GIBS	Gordon Institute of Business Science
HBS	Harvard Business School
HDI	Human Development Index
HIV/AIDS	human immunodeficiency virus / acquired immunodeficiency syndrome
HR	human resources
HTMT	heterotrait-monotrait
IAMOT	International Association of Managers of Technology
IBM	International Business Machines Corporation
ICT	Information and Communications Technology
IL	integrative leadership
ILQ	innovation leadership questionnaire
IP	intellectual property
IQ	intelligence quotient
ISI	Indian Statistical Institute
IT	Information Technology
IWB	innovative work behaviour (model)
LCV	lowest critical value
LEAPS	Listen, Explore, Act, Persist, Seize
LED	light-emitting diode
LMS	liberating mindsets
LMX	leader-member exchange
MBA	Master of Business Administration
MBI	Master of Business Innovation

MIT	Massachusetts Institute of Technology
MOI	management of innovation
MOT	management of technology
MSG	Media Solutions Group
NACI	National Advisory Council on Innovation
NASA	National Aeronautics and Space Administration
NIPF	National Industry Policy Framework
NRDS	National Research and Development Strategy
NRF	National Research Foundation
NSI	National System of Innovation
NSTF	National Science and Technology Forum
OECD	Organisation for Economic Co-operation and Development
PESTLE	Political, Economic, Social, Technological, Legal, Environmental (factors)
PhD	Doctor of Philosophy
PLS-SEM	Partial Least Squares Structural Equation Modelling
PoPI	Protection of Personal Information Act
R&D	research and development
RISC	reduced instruction set computer
RSA	Republic of South Africa
S & T	science and technology
SAINE	South African Innovation Network
SARChI	South African Research Chairs Initiative
SARIMA	South African Research and Innovation Management Association
SCRI	Symbiosis Centre for Research and Innovation
SET	science, engineering and technology
SHA	stakeholder alignment
SHRM	Society for Human Resource Management
SME	small and medium-sized enterprise
SMS	short message service
SO	success orientation
StatsSA	Statistics South Africa
Std. dev.	standard deviation
STEEP	social, technological, economic, ecological and political
TC	technology connectedness
TILCS	Technology innovation leader competencies
TIM	Total Innovation Management (framework)
TQM	Total Quality Management
TRLs	technology readiness levels

TYIP	Ten Year Innovation Plan
UK	United Kingdom
UNESCO	United Nations Educational, Scientific and Cultural Organization
US$	United States dollar
USA	United States of America
USPTO	United States Patent and Trademark Office
VC	value creation
VR	value realisation
VUCA	volatile, uncertain, complex and ambiguous
WIPO	World Intellectual Property Organization

CHAPTER 1
RESEARCH INTRODUCTION AND RATIONALE

1.1. CHAPTER INTRODUCTION

Much of what differentiates modern society from historic or ancient societies could be traced back to man's ability to innovate in the form of technological advancements that were inspired by leaders (McKeown, 2014). Innovation is not new, neither is technology, nor leadership. However, scholarly attention to the leadership of innovation, is relatively new. Early research findings suggest that innovation leaders require distinctively different leader competencies for success in the innovation economy than those deemed to be appropriate for the industrial or even the knowledge economy (Business Week, 2004; Hill, Brandeau, Truelove & Lineback, 2014). Leaders of innovation in organisations are becoming more involved in getting better and more ideas processed into strategic value as competition increases, while the competencies that they require for successful innovation are not always known (Arthur D. Little, 2015).

New technology has been advancing man's performance capabilities, initially in a physical sense such as energy, transportation and production functions. Similarly, information and communication technology (ICT) has been advancing man's cognitive capabilities and democratisation leading up to the so-called knowledge economy (Brynjolfsson & McAfee, 2014). The phrase "Knowledge is power" dates to 1597 when Francis Baker, often regarded as the father of scientific methods of enquiry, published the phrase (Dictionary.com, 2015). Knowledge has since become more accessible than ever before, resulting in a shift towards the application of knowledge for value creation (Business Week, 2004). Organisations differentiate themselves through value creation based on the application of available knowledge and leveraging technology innovation, which accounts for up to 80 percent of economic growth (Heles, 2015; Kakaes, 2012; Solow, 1956).

South Africa has declared technology innovation as a priority in national level policy and planning (Department of Science and Technology, 2008). Performance indicators, however, reveal performance gaps in several important areas where competent technology innovation leaders could be instrumental in improving performance against plans. The limited body of knowledge pertaining to what competent technology innovation leaders do to achieve successful technology innovation, leaves technology innovation leaders with a knowledge gap about the leader behaviours deemed necessary for successful technology innovation (Steyn & Bell, 2016:10).

This study investigated technology innovation leader competencies deemed to be required for successful technology innovation. This introductory chapter sets the scene for the research presented by reflecting on the so-called "innovation economy" (Business Week, 2004: front cover) and innovation at societal, business and technological levels before presenting the rationale for this study, followed by an overview of the scope of this study as illustrated in Figure 1.1.

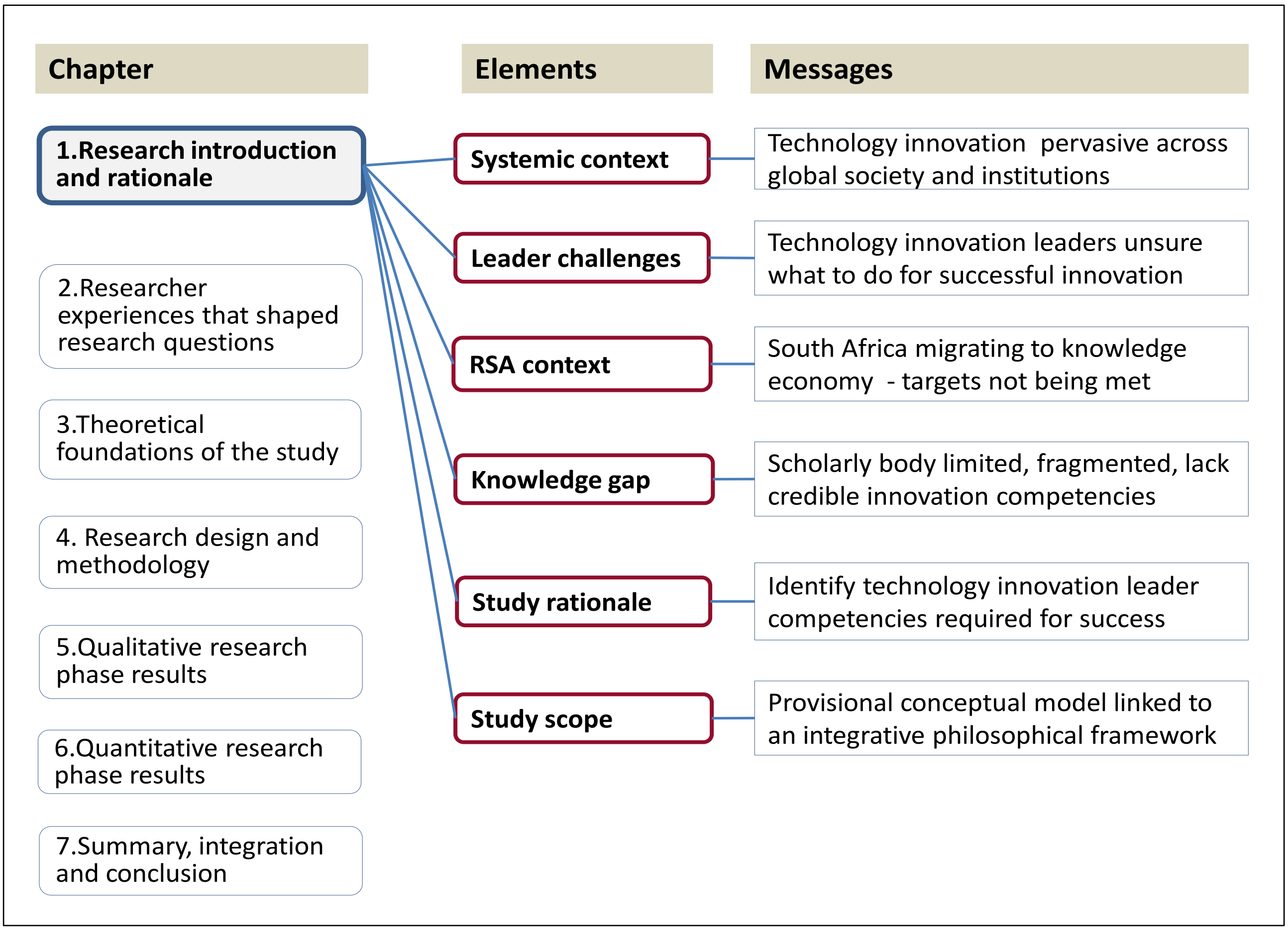


Figure 1.1: Thesis map of Chapter 1

1.2. TECHNOLOGY INNOVATION IN SYSTEMIC CONTEXT

Modern-day technology innovation is taking place across boundaries. With the "...explosion of wireless communication in the early twenty-first century, we can say that humankind is now almost entirely connected" (Castells, 2014:1). Reflecting on the notion of innovation as creative destruction, introduced by economist Joseph Schumpeter in 1942, it is noted that evolving institutions in society, entrepreneurs and technology changes were at the heart of economic growth, prosperity and wealth; all of which are becoming systemically more connected and interlinked (Hoque, 2013; Muller, 2013).

Society and its institutions face an evolving set of interrelated challenges and opportunities in a volatile, uncertain, complex and ambiguous (VUCA) world that requires unprecedented creativity and successful implementation of innovative solutions such as new technologies (Aspen Institute, 2015; Berthon, Hulbert & Pitt, 1999) Complex interwoven societal challenges, such as population growth and food security (Binedell, 2011:1), hunger, health, poverty, unemployment, inequality, corruption, terrorism and environmental destruction, affect the future sustainability of society and require more than quick fixes at the level of single elements (Metcalf, 2014; Sen, 2011:9; Speth, 2008:i).

In response to societal challenges individuals have been inventing tools and technologies to extend man's ability to cope and perform work with greater ease and efficiency. The legendary Italian inventor and innovation leader, Leonardo da Vinci, is often described as the Renaissance man in Italy who influenced much of the revival in art, literature and intellectual achievements in Europe between the 14th and 16th centuries, through his extraordinary range of competencies across different disciplines. His curiosity and inventive imagination inspired himself and others to explore the unknown in pursuit of new possibilities in art, painting, sculpture, mathematics, geology, cartography, botany, architecture, engineering, anatomy, writing and music. His technological ingenuity enabled him to conceptualise flying machines, armoured vehicles, concentrated solar power, adding machines, double hulls and to outline a theory of plate tectonics (Capra, 2007; Gelb, 2004).

Thomas Alva Edison (1847-1931), another legendary technology innovation leader, inventor and business leader, is often described as someone who used the innovative capabilities of other people to realise new possibilities. He is well known for suggesting that, if we all did the things we are capable of doing, we would literally astound ourselves. As one of the first inventors to apply the principles of mass production and large-scale teamwork to the innovation process, his work and 1 093 patents significantly influenced new technology developments, such as the phonograph, the motion picture camera and the electric light bulb. His work has also contributed towards mass telecommunications, a stock ticker, a mechanical vote recorder, a battery for an electric car, electrical power, recorded music and motion pictures (Thomas Edison Center, 2017).

A polymath is a person whose expertise spans a significant number of different subject areas. This Greek word is used to describe a person of great or varied learning (Morris, 1981) and could be used to describe the exceptional range of talents, capabilities, competencies and knowledge that both Da Vinci and Edison have brought to bear in their technology innovation. While these two polymaths have been widely acknowledged for their inventiveness, several questions may be asked about the polymaths of the 21st century relating to their identification, their contributions and, more importantly for this study, the leadership competencies required of those responsible for technological innovation in modern knowledge-intensive organisations (Hoque, 2013).

With access to latest technologies, modern-day polymaths may no longer be restricted to specific roles and positions in organisations. "Community is formed through individuals' quest for like-minded people" and technology is making it easier for them to interact irrespective of institutional boundaries (Castells, 2014:2). Innovation in the 1970s focused mainly on research and development (R&D) and personal creativity. R&D was essentially about developing new technologies and products in scientific research centres, while personal creativity was about enhancing the creative potential of people, other than the lone inventors and entrepreneurial visionaries who dared to dream and to come up with breakthrough ideas. Neither of those two streams was particularly interested in how innovation success could be improved through innovation in operational processes, services, cost structures, customer experiences, business models, management practices, or industry architectures (Kelley, 2010).

Bruton and White (2011) emphasised the dynamic nature of both technology and innovation, pointing out that technology and innovation influence the firm and society in an on-going manner. Entire industries can disappear quickly because of unexpected technology innovation being introduced. Technology is an integral part of most organisations today. It is typically pervasive in ways that may not be fully appreciated until it is further explored in depth. Any organisation that ignores technology innovation does so at great risk. It is becoming increasingly difficult to draw boundaries around technology innovation or to limit the influence of technology innovation to any person, organisation or region. Technology innovation has made it possible for people to be away from the office, but not out of contact. Technology innovation in mobile technology, for example, makes it possible for people to work from locations other than the office. As a result, new management mechanisms may have to be introduced to integrate and manage these individuals differently from employees who are physically present (Bruton & White, 2011:11).

The demands of the innovation economy are more systemic in nature and require a better understanding of technology innovation and the competencies of leadership required to bring about value creation through technology innovation in business and society, as discussed in the sections below. Considering the key role of technological innovation within the innovation economy today, this study approaches technology innovation as a phenomenon embedded in different spheres of human endeavour, where leadership plays a role in bringing about value creation through innovation.

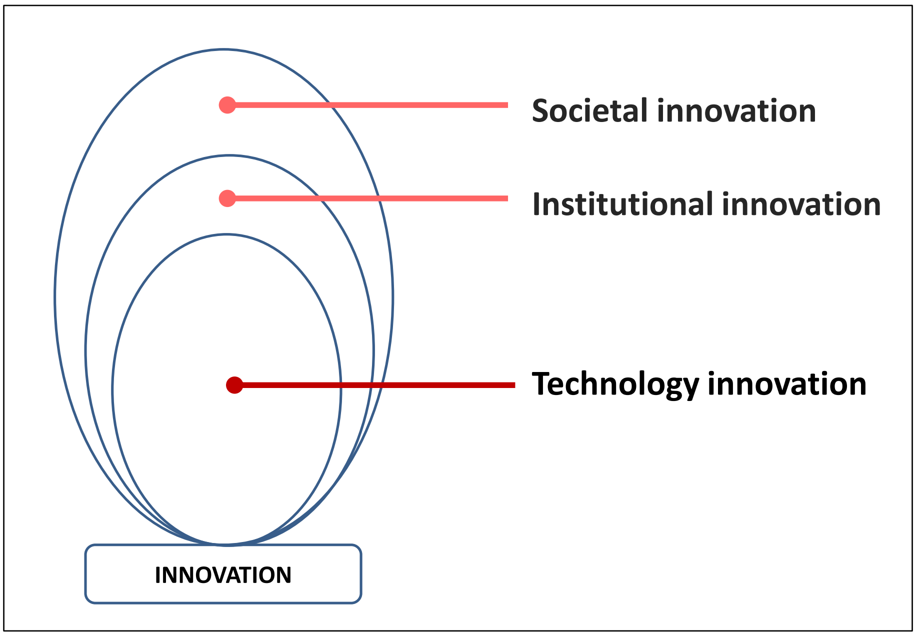


Figure 1.2: Technology innovation in systemic context

Figure 1.2 indicates that this study does not view technological innovation as being separate from societal or business innovation, but rather as an integral part thereof by either responding to changes in society or business, or by triggering changes in society or business.

Each of the interrelated systems in Figure 1.2 are briefly contextualised for this study into technology innovation leader competencies, while more discussion on innovation typologies and their relevance to this study follows in later chapters.

1.2.1. Societal innovation

Emphasis on innovation to help solve problems and address challenges in society is being expressed by its leaders, for example:

- United Nations Secretary General, Ban Ki-moon: "How do we lift people out of poverty while protecting the planet and eco-systems that support economic growth? How do we regain the balance? These issues require rethinking, revolutionary thinking and revolutionary action. Leaders who spark innovation and lead by action" (Ki-moon, 2011: 3).
- European Commission President, Jose Barroso, sees innovation as the only way to achieve a sustainable exit from the global economic crisis and to achieve growth and competitiveness of all sectors of economy and sustainable society (Barosso, 2011).
- World Health Organisation Director-General, Dr Margaret Chan, calls for innovation to address health challenges (Chan, 2011).
- The emerging economies of the world also require innovation to deal with their socio-economic and global competitiveness challenges (Mashelkar, 2010:547).
- In the South African national policy context, innovation in science and technology is considered crucial to developing a more competitive foothold in the global economy, and to "...addressing pressing developmental needs" (RSA, 2007:25). Innovation is key to South Africa's global competitiveness (Van Jaarsveld, 2014).

1.2.2. Institutional innovation

Institutional innovation capacity is increasingly being established by public, private, professional institutions and organisations generally as dedicated functional areas (Miller, Klokgieters, Brankovic & Duppen, 2012). While some focus on the building of an innovation eco-system as a priority, others have matured their innovation capabilities sufficiently to be recognised in innovation awards programmes such as the Technology Top 100 Awards Programme (Davinci TT100, 2016) and the National Science and Technology Forum Awards (NSTF, 2016).

Early signals for institutions to prepare for the innovation economy came in the form of "Innovate or die" messages appearing in management literature in the 1980s and 1990s (Drucker, 1982; Peters, 1997). "...You better be trying stuff at an insanely rapid pace. You want to be screwing around with nearly everything. Relentless experimentation was probably important in the 1970s – now it's do or die" (Peters, 2014:1).

Harvard Business School (HBS) professor, Clayton Christensen, appears to have been the first in 2002 to refer to innovation as “the new science of success” and predicted that innovation would become a new management discipline (Christensen, 2002:33). Renowned strategy expert, Gary Hamel, joined Christensen in calling for innovation in traditional management practices and claimed that companies would soon be forced to change in ways for which no precedents exist (Hamel, 2011:1).

Organisational managers surveyed tend to endorse the rising significance of innovation. However, they report a range of constraints, such as a lack of an innovation strategy, lack of suitable governance mechanisms and lack of understanding of innovation skills required (Steyn & Bell, 2016:10).

While the abovementioned calls for help may come as a surprise to some, Drucker (1982:503) anticipated such scenarios over three decades ago when he wrote: “An established company that, in the age demanding innovation, is not capable of innovation is doomed to decline and extinction. And a management that in such a period does not know how to manage innovation is incompetent and unequal to its task. Managing innovation will increasingly become a challenge to management and a test of its competence.”

1.2.3. Technology innovation in societal context

Technology has become a significant, if not the most important, enabler of human activity in modern society. Technological change and scientific advances are drivers of economic performance. According to the Organisation for Economic Co-operation and Development (OECD) (2000), the ability to create, distribute and exploit knowledge is being acknowledged as a major source of competitive advantage, wealth creation and improvements in the quality of life.

The human ability to bring about technology innovation has developed to become a critical part of societal activities. Economist Joseph Schumpeter was an early observer of this phenomenon, resulting in his theory of creative destruction which underpins innovation (Schumpeter, 1942). The technology innovation leader operates within a context in which stakeholders have come to expect technology innovation to bring about improvements. Table 1.1 conveys examples of work productivity improvements that had been achieved through technology innovation.

Table 1.1: Examples of work productivity improvement through technology innovation

Examples	Craft production 1913 (in minutes)	Mass production 1914 (in minutes)	Improvement %
Engine production	594	226	62
Magneto production	20	5	75
Axle production	150	26.5	83
Components fitment	750	93	88

Source: Adapted from Smith, 2010.

Table 1.2 conveys examples of societal improvements that had been achieved through technology innovation.

Table 1.2: Examples of societal improvement through technology innovation

Examples	Societal improvement
Jet engine	Permits mass travel
Carbon fibre F1 chassis	Better handling & safer car
Transistor radio	Portable/mobile radio
Personal computer	Computing for all
Digital camera	Photography more flexible/accessible
MP3 player	Greater access to recorded music

Source: Adapted from Smith, 2010.

Technology advancement plays a pivotal role in economic growth (Solow, 1956; 1974) and is increasingly being used to enhance socio-economic development. While some sources emphasise the destructive impact that technology adoption has had on certain sectors, others relate to the potential for job creation and economic stimulation brought about through technology innovation (Nizeyimana, 2013). While some organisations have acknowledged technology innovation as an organisational critical success factor in leadership and enterprise success, Collins (2001:12-14) made it clear that "...technology by itself is never a primary root cause of either greatness or decline," but that breakthrough leadership requires a more appreciative perspective on the role of technology. Table 1.3 provides a summary of socio-economic contributions from technological advancement.

Table 1.3: Socio-economic contributions from technological advancement

Element identified	Description
Communication	Communities of interest and practice, more sophisticated terminology and networking
Competitiveness	Value creation based on competitive advantage from using technology.
Entrepreneurship	Stimulation of start-up firms using technology to generate income.
Human capital development	Knowledge transfer and self-help.
Investment	Attracting investor funds in anticipation of positive returns on investment. Building trade capacity.
Job creation	Technology allows for appointment of people in income-generating positions.
Poverty reduction	Technology as key policy instrument in poverty reduction and sustainable economic development.
Productivity	Improved efficiency. Being able to produce offerings faster or at reduced cost.

Source: Adapted from Nizeyimana, 2013.

Where organisations have been the dominant developers, providers and users of technology, individuals now also have access to ever-increasing ranges of technology.

> *Virtually everything imaginable (people, machines, natural resources, production lines, logistical networks, consumption habits, etc.) can be linked together via sensors and software. This provides a constant stream of big data that can be processed through advanced analytics and algorithms that search for patterns and insights* (KR Conferences, 2016:1).

It can be argued that the role of technological innovation has become all pervasive in the modern society. The use of social media, for example, is noticeable in governments, businesses and in households, with less noticeable boundaries between users, functions and applications.

Technology innovations that are labelled as leading edge because of their potential to disrupt current practices are introduced daily and include, for example, robotics, artificial intelligence, digital laser, driverless vehicles, an electronic tongue for tasting and alternative energy (Butler, 2014:1). These examples, albeit a small randomly-selected sample from just one of many daily news reports on technological innovation, appear to have at least one salient feature in common; they may all be adopted by society in which case they would then disrupt and replace the existing practices because of their superior performance (Christensen, 1997; Christensen & Raynor, 2013).

The preceding discussion represents a brief introduction to a recurring theme that will be expanded throughout the thesis to leave the reader with some appreciation of the pace and magnitude of technological advancement being observed by scholars such as Brynjolfsson and McAfee (2014), as well as Schwab (2016). These observations were presented as introduction to a research conversation about leaders and particularly those leaders with dedicated responsibility for technology innovation.

1.3. INNOVATION CONSEQUENCES FOR LEADERS

The image of rippling, repeating circles of water emanating from the point where a stone is dropped into a pond was one of Leonardo da Vinci's favourite images that conveys the radiating effect of his work over nearly five centuries (Gelb, 2004). Modern day technology innovations create rippling effects much faster and at global levels of magnitude beyond the control of the individual leader and provide no manual to leaders (Phapruke, 2011). A growing body of management literature conveys the importance of innovation and the need to review leadership requirements for innovation success at institutional and individual levels of competence (Kaskhedikar, Rahate & Rewatkar, 2013; MacDonald, 2010:24).

As technology innovation continues to influence society and automate tasks previously performed by humans, leaders create new jobs and industries from technology innovation. Brynjolfsson and McAfee (2014:171) claimed that this is not accomplished by well-meaning government leaders or visionary academics, but by ambitious entrepreneurs like Thomas Edison, Henry Ford and Bill Gates as technology innovation leaders who created new industries that more than replaced the work that was eliminated. According to these authors (Brynjolfsson & McAfee, 2014:171), the current transformation of the economy that they describe as “the second machine age” creates equally-large opportunities for leaders.

With humankind now almost entirely connected through technology and social networking sites becoming preferred platforms for personal and business sociability, messages no longer flow from the few to the many with little interactivity. Messages now also flow from many to many, multi-modally and interactively and not through societal and institutional structures (Castells, 2014). This hyper-connected innovation economy makes innovation possible through access to knowledge, no longer requiring complex corporate structures or massive factories, no longer constrains technology innovation to physical borders, cultures and disciplines, but requires changes in leadership practices for sustainable success (Hoque, 2015).

Scholars are beginning to claim that the success behaviours of innovation leaders differ from the success behaviours found in conventional operations’ leadership practices. These research findings (Hill *et al.,* 2014; Swart, 2013) may be a step towards filling the knowledge gap, but contextual and sample-related limitations of reported findings limit the extent to which they could be extrapolated into other organisations, groups or leaders. The quest thus continues to identify technology innovation leader competencies deemed to be required for successful technology innovation as discussed from several leader perspectives below.

1.3.1. Leading technology innovation for competitiveness

Innovation has been described as the only remaining legal way to gain an unfair advantage over competitors and achieve the differentiation required in modern society for the continuing success of organisations in the challenging management landscape of the early 21st century (Taljaard, 2013). The bridging transition from what can be imagined to the creation and realisation of value can be seen as the essence of innovation (Wu, 2013). For greater competitiveness, co-creation between players in supply chains have become popular, but has brought even more pressure to innovate, because if the innovation is successful, others are likely to copy and produce even more options to customers, which in turn, leads to more innovation (Berthon *et al.,* 1999). Statements like “Innovation distinguishes between a leader and a follower” indicate that technology innovation is being viewed as a source for differentiated offerings or competitive advantages in the market place that both emphasise the importance of leading innovation in the modern economy (McKeown, 2014:135).

In his seminal publication *The Innovator's Dilemma,* Clayton Christensen (1997), refers to new disruptive technologies causing great firms to fail. These are innovations that break the pattern of firms producing higher-specification products at higher prices using established technologies. When introduced, disruptive technologies initially offer poorer performance than established technologies, but are cheaper and provide more benefits. Firms that adopt these at an early stage may outperform others and eventually force others to join in using the technology or force them to exit the market due to increased competitive pressures. Examples of previously introduced disruptive technologies that created new markets and business models while eliminating former market leaders include the computer, cell phone and digital photography. HSBC, one of the largest banking and financial services institutions in the world, employs a team of analysts worldwide to track and anticipate trends and identify businesses that are being revolutionised by new technology or shifts in business models. One of the many current examples presented by HSBC is light-emitting diode (LED) lights that offer 50 000 light hours at a total cost of US$ 78.57 against a total cost of US$ 326.79 for incandescent technology (Evans, 2013:49).

Xu, Chen, Xie, Liu, Zheng and Wang (2007:10) claimed that increasing global competition results in firms increasingly being expected to innovate across more areas of responsibility than before. Driving factors include the increasing cost and complexity of products and services, information technology (IT) based innovation networks, accelerating industrial change and shortening technology lifecycles that compel firms to innovate. There is also a growing realisation that innovation and organisational change are highly interconnected. Xu *et al.* (2007:10) presented evidence that 68 percent of 1 900 Danish private firms surveyed had also undertaken major organisational changes parallel to innovation. Firms that had not innovated only reported 34 percent organisational changes.

Staying competitive amidst constant turbulence and disruption is one of the greatest challenges for business leaders today. Current structures and processes that form the operating system need a second operating system that uses an agile, network-like structure and different processes to continually assess the business, the industry, the organisation and react with greater speed, agility and creativity than the current one (Kotter, 2012; Leavy, 2014).

1.3.2. Leading technology innovation for economic growth

Based on the work of Nobel laureate, Robert Solow (1974), up to 80 percent of economic growth can be attributed to technology innovation (Lochner, 2011). Innovation is firmly recognised as a central driver of economic growth and development, and increasingly so also in developing countries (Insead, WIPO & Cornell University, 2015).

Technology innovation brings about new possibilities in human achievement and performance. Henry Ford introduced mass production as a new production technology and in the process reduced the time taken to produce a car from 12 hours to 90 minutes (Smith, 2010). Technology innovation allows for the creation of new value by enabling people to accomplish what has not been possible before through human action, or enables people to bring about new products, services or processes in new ways to expand the realm of practical human possibility and support economic activities (Bruton & White, 2011; Smith, 2010).

Research on the role of innovation in the economy and social change has proliferated in recent years (Fagerberg, 2003) but the question about what leaders do to influence innovation performance remains unanswered (Wittenberg, 2011).

1.3.3. Leading technology innovation in the innovation economy

Literature on leadership and innovation leadership seldom makes specific reference to technology innovation leadership. Even when reference is made, it is not always clear if leadership means a market position for an entity, a level in an organisation, or a group or individual - the latter being the focus of this study (Gliddon & Rothwell, 2016). When case references are made, however, they usually include technology innovation organisations, which legitimise its use as input-material to this study.

The study of the cause and effect relationships between leading innovation and innovation performance has been inconclusive. Some claim that innovation is too complex for leaders to effectively influence performance (Mumford & Licuanan, 2004: 164), while others claim leadership as the best predictor of innovation performance (Barsh, Capozzi & Davidson, 2008).

Mumford and Licuanan raised concern about attempts to claim causality in the role of leaders shaping the nature and success of creative efforts because it entails “an unusually complex activity”.

> *...it is not a ‘given’ that leader behavior actually exerts noteworthy effects on creativity and innovation … although it seems clear that leadership does make a difference with respect to creativity and innovation, the conditions that make it possible for leaders to effectively exercise influence in this regard are, at least at this juncture, less clear.* (Mumford & Licuanan, 2004: 164)

Some scholars appear to be more convinced that competent leaders positively influence innovation performance, as reflected in the following contributions.

In a 2004 publication by the McGraw-Hill publishers that was devoted to the “innovation economy”, they highlighted a growing emphasis on innovation and anticipated increasing innovation speed and magnitude, as well as its impact on management practices. They emphasised the increasing significance of technology innovation (Business Week, 2004:8).

More than a decade later scholarly interest in the relationship between leaders and innovation performance are beginning to result in research claims, for example:

- Leaders shape innovation performance; innovation leadership is required to address the "Inspiration Gap" for the United Kingdom (UK) to remain competitive and "...adopt strategies that will enable a greater level of innovation and the provision of high value goods and services" – Department of Trade and Industry (DTI) Innovation Review (Baker, 2003:3).
- Management is about directing people, efficiency, structuring and organising. Innovation leadership is critical to innovation success and is about inspiring individuals to higher levels of performance, to go the extra mile – which is often required in innovation (Von Stamm, 2009).
- "CEOs now realise that creativity trumps other leadership characteristics" as reported by IBM in their global CEO study (Berman & Korsten, 2014; McDonald, 2010).
- Innovation is becoming the most important leadership competency for the 21st century (Sernack, 2013).
- The innovation challenge is to mobilise knowledge and technological skills and experience to create value (Tidd & Bessant, 2013).
- As uncertainty increases, "the way we manage has to change" which "requires a new style of leadership" in order to turn their organisations into successfull innovators" (Furr & Dyer, 2014:36).
- Both innovation and leadership have been researched, but research on leadership of innovation is new (Hill, 2014).

When leaders are accountable for results but have little influence, it is not clear to what extent they influence innovation decisions where it becomes "...difficult to define the value proposition of technology investments" in enabling technologies unless technology is evaluated by influence of architectural decisions on the system being considered (Battat, Cameron, Rudat & Crawley, 2014:1). When the future is yet to be created and the leader has to deal with uncertainty, traditional approaches may fall short. Uncertainty requires creative management responses and novel coping mechanisms, making decisions based on incomplete information. In the innovation economy, it is critical to manage unexpected events with minimal disruption and without resorting to crisis management. Organisations must perfect the art of imagining a future and endeavour to build on it, with dynamic capabilities to ideate, test and deploy new innovations (Teece, Peteraf & Leih, 2016).

Effective innovation in the innovation economy requires systemic leadership impact that stems from collaboration, vision and the will to direct progress for long-term growth by harnessing organisational innovation potential through leadership mandates and actions for a sustainable future (Hoque, 2013). Innovators in a firm may feel like immigrants in a strange land, who are not fluent in the internal lingo and insufficiently aware of cultural and political factors that may cause innovation fatigue, which could be prevented by appropriate leadership (Lindsay, Perkins & Karanjikar, 2009).

The innovation economy is defined by revolution which requires dynamic capabilities:

> *…just when you think you've got it all figured out ... everything will change in an instant. The best organizations are agile. When faced with deep uncertainty, they arm themselves with information. They seize new opportunities. And they transform entire industries. What was once optional is now essential. Evaluate every tool. Uncover every advantage* (Teece *et al.,* 2016).

Knowing when and how much agility is needed, is a crucial managerial capability and agility can be through dynamic capabilities, including sensing, seizing and transforming. Sensing ("proactively hypothesising about future implications of perceived trends") and seizing include identification, development and evaluation of technology opportunities in relation to customers' needs, while transforming concerns continued renewal (Teece *et al.,* 2016). The 20th century 'push' model, in which success was based on achieving economies of scale markets, was appropriate for a world in which markets were relatively stable and predictable. This is being replaced by a 21st century 'pull' model based on scaling continuous learning to keep pace with a constantly-evolving market place (Aspen Institute, 2015) Successful innovation leaders need to adapt to a changing environment to avoid becoming a 'mussel', which is a term that implies that a leader may become ignorant to changes taking place in the technology innovation field (Kets de Vries, 2001:58).

"There is no reason for an individual to have a computer in his home", was a statement made by Olson who founded Digital Equipment Corporation. This statement was symptomatic of his inability as leader to adjust and that may have been a major reason for the firm to fall from being 7th in the Fortune Magazine 'hit parade' to number 386 before he was pushed out of the firm (Kets de Vries, 2001:57-58).

Having studied leadership in complex environments, Goffee and Jones (2009:10) claimed that complexity "...demands coordination and clever people – and inspired leadership". They emphasised that these include people who "...are capable of great things, but only if the organisational and leadership context enables them to realise their potential" (Goffee & Jones, 2009: XVI). They claimed that clever people are "highly talented individuals with the potential to create disproportionate amounts of value from the resources that the organisation makes available to them" (Goffee & Jones, 2009:3). Leaders of clever people determine whether their organisation is a "...hub of clever collaboration or a toxic talent pool" (Goffee & Jones, 2009:18).

Post-industrial era work may be too complicated to boil down into a single slogan describing work, but three scenarios seem to be emerging: (i) processes are automated and robotised, leading to an algorithmic economy; (ii) generic work is accessed through platforms, or turned into tasks circling the world, leading to a platform economy; and (iii) context-specific value creation takes place in interaction between interdependent people, leading to an entrepreneurial economy (Kilpi, 2015a).

Increasing digitisation of manufacturing may suggest a future inflection point where the availability of computing power, memory, and the literal connectivity around high-speed networks are making man's ability to connect factories (and the knowledge that's required to run factories) a reality.

> *We couldn't do this effectively as little as five years ago... now we have the software capability and the IT capability to embed this kind of fabric into everything we do in the manufacturing realm – from ideation through modeling, simulation, testing, and then the actual manufacturer service, and even through the decommission step* (Salvo, 2015:2).

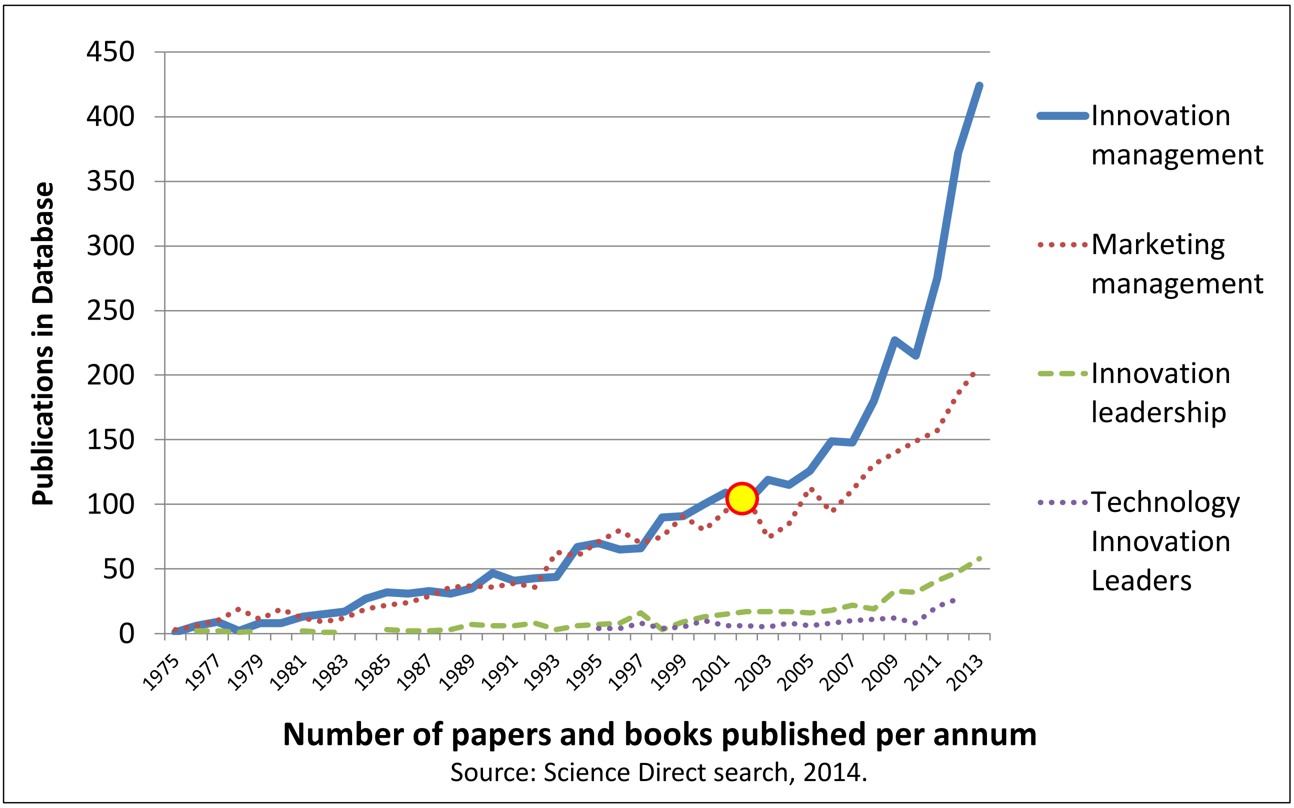
It should be clear from the points raised above that those with leadership responsibilities in general and technology innovation leaders in particular, face an evolving set of challenges and opportunities for which answers may not yet exist but might come from creative thinking and leadership that makes it possible. Many societal issues point to the need for economic growth. If economic growth is the way out, innovation is the means. Innovation is seldom a solo activity and most often takes place within networks bringing people together in ways that encourage creative thinking to be turned into action. Understanding innovation is about understanding how people interact through their social networks (Aspen Institute, 2015).

The innovation capabilities of leaders will ultimately determine the competitiveness of their organisations. As players in the highly-competitive innovation economy, which is influenced by factors such as a global population increase, global climate changes and increasing competition for available resources, the need for organisations to innovate has never been greater (Damanpour, 1997; Gopalakrishnan & Damanpour, 1997; Hogan & Coote, 2014; Kuratko, Morris & Covin, 2011; Von Stamm, 2012).

1.3.4. Increasing scholarly interest in leading technology innovation

In a special report featured in their 75th anniversary issue, the McGraw-Hill companies emphasised that what they referred to as the "innovation economy" was about to escalate in terms of speed and magnitude, as well as its impact on management practices. The technology innovation section of the special report reads: "We've walked on the moon, built the Net, and decoded the genome. Have we run out of worlds to conquer? No, as a matter of fact, we're on the cusp of a fresh innovation boom" (Business Week, 2004:8).

An innovation boom may also be an appropriate descriptor for the exponential growth in the scholarly body of knowledge on innovation management and increasing interest in innovation leadership and technology innovation leaders in recent years. Figure 1.3 reveals rapid growth in innovation management literature relative to the marketing management field used here as a benchmark. The annual number of papers and books published on innovation management has grown from 102 in 2003 to 413 in 2013 (304.9% increase), 17 to 58 in innovation leadership (241.2% increase) and 5 to 27 (440% increase) in technology innovation leadership.



Note: Yellow dot shows Christensen (2002:33) reference to innovation as a new science of success.

Figure 1.3: Number of papers and books published per annum

Source: Compiled by the researcher from Science Direct, 2014.

Despite the significance of technology innovation in the modern society and the extensive knowledge base pertaining to leadership, the literature reviews revealed scholarly contributions that are fragmented, non-integrated and insufficient to compile either a theory for, or a profile of technology innovation leader competencies that are required for successful execution of the innovation process, or what is also referred to as the “Innovation Value Chain” (Hansen & Birkinshaw, 2007).

Management scientist Peter Drucker (1982:500) wrote: “The need to innovate is mentioned – indeed emphasised – in every book on management” but they had little to say about what management and the organisation need to be and do to stimulate, direct, and bring about effective innovation. His concern was that most books cover the administrative functions of management that relate to the task of keeping going and improving what is already known and done. Little thought, he suggested, was “...devoted to effectively and purposefully” creating the new and the different and integrating these with the organisation and its structures.

According to Drucker (1982:502), existing organisations would have to become "... capable of organising themselves for innovation, as well as administration".

Some sources claim that the success behaviours of innovation leaders are indeed different from the leadership behaviours that are deemed to be sufficient in conventional leadership (Elkins & Keller, 2003; Govindarajan, 2010; Hanna, 2009; Lafley & Charan, 2010; Teece, 2009). Other authors have also expressed the need to review leadership practices and competencies required for innovation success from institutional (Phapruke, 2011:43) to individual levels of competence (MacDonald, 2010:24; Kaskhedikar *et al.,* 2013; Von Stamm, 2012). Both innovation and leadership have drawn the attention of authors and management scientists for decades, but linkages between the two have only recently entered the management research agenda, while leaders are still looking for ways to blend individual and collective genius (Hill *et al.,* 2014).

1.3.5. Leading technology innovation – a provisional synthesis

A provisional synthesis of the preceding discussions is presented here to contextualise the innovation landscape in which the technology innovation leader operates, before shifting the broad introductory perspectives towards some specifics pertaining to technology innovation leaders in South Africa, also referred to as leaders of innovation (Von Stamm, 2013).

- Technology innovation is becoming increasingly important in identifying and addressing societal and business challenges across organisational, functional and geographic boundaries (Bruton & White, 2011; Hoque, 2013; Metcalf, 2014; Sen, 2011; Speth, 2008).
- With the growing significance and influence of innovation and technology, innovation leaders are confronted by new unprecedented challenges that require leader competencies that differ from traditional management practices (Barsh *et al.*; 2008; Business Week, 2004; Hill *et al.,* 2014; Kaskhedikar *et al.,* 2013; Kets de Vries, 2001; MacDonald, 2010; Phapruke, 2011).
- Nearly all of 1 228 participating managers in a South African survey viewed innovation as an opportunity for their organisations to differentiate themselves from competitors; 47 percent did not have innovation objectives in their business plans; and 32 percent believed that they did not have the right skills, processes and environment for achieving innovation success (Steyn & Bell, 2016:10).
- Organisations are designed for efficiency rather than innovation and the daily pressures of business are hard to combine with the risks of innovation, resulting in conflict between innovation and operations (Battat *et al.,* 2014; Govindarajan & Trimble, 2010; Kilpi, 2015b; O'Reilly, 2011; Von Stamm, 2009).

- Technology innovation is moving away from individual genius towards increasingly enabling global interconnectedness of all humankind. The "knowledge is power" paradigm is shifting towards a paradigm of accessing and applying knowledge for value creation through cognitive capabilities collectively (Capra, 2007; Castells, 2014; Gelb, 2004; Heles, 2015; Hoque, 2013; Kakaes, 2012; Solow, 1956).
- Scholarly interest in innovation and innovation leaders has been growing exponentially resulting in more appeals for integration of leader competencies for innovation and development of theories to understand technology innovation (Berthon *et al.,*1999; Drucker, 1982; Leiponen & Helfat, 2010; McKeown, 2014; Miller *et al.,* 2012; Science Direct, 2014; Sernack, 2013, Smith, 2010, Tidd & Bessant, 2013).

The emerging research question not answered yet is: "What are the technology innovation leader competencies deemed to be required for successful technology innovation?" As discussed in Chapter 3, competency and competencies relate to leaders while competence and competences relate to organisations. The main research objective for this study is thus to identify the technology innovation leader competencies deemed to be required for successful technology innovation.

The researcher argues that, until scientifically-derived innovation leadership competencies are available to serve as benchmark for innovation practitioners, technology innovation leaders might go from one source of opinion to another in their quest to identify and master competencies on offer. Entrepreneurial offerings in the innovation capacity-building field are increasingly targeting leaders in society to attend their courses. An example of such an invitation (Thoughtleaders, 2014) follows:

> *Leaders are realizing that in order to safeguard a sustainable business into the 21st century and beyond, they need to transition from creating short-term shareholder value to creating long-term, inclusive wealth for all stakeholders and to shift from business as usual to innovative, out of the box thinking. Change is the 'new normal'. Executives, business leaders, and decision-makers faced with this daunting task of retooling and revitalizing their enterprises for change, need thought leadership, tools and networks to successfully embed a culture of Innovation in their organisations. Learn how to gain a competitive edge by joining us for this Executive Innovation Workshop.*

This brochure (Thoughtleaders, 2014) contains no references to scholarly sources or how the learning content had been identified or processed and validated to address the competency development requirements of technology innovation leaders.

1.4. SOUTH AFRICAN TECHNOLOGY INNOVATION IN GLOBAL CONTEXT

This study investigates technology innovation leader competencies that are deemed to be required for successful technology innovation in knowledge-intensive organisations in South Africa. The preceding discussions extend beyond the boundaries of South Africa. This section emphasises the South African situation as it pertains to technology innovation leaders in the National System of Innovation (NSI) which is often inextricably linked to the global innovation landscape as discussed. This interdependency between South Africa and the rest of the world regarding technology innovation is emphasised before drawing conclusions on the knowledge gap underpinning this study as basis for the formulation of the research rationale, scope and thesis overview.

1.4.1. South Africa relative to the global innovation landscape

Internationally-acknowledged innovation benchmark reports include ratings for South Africa. All the reports suggest that South Africa can improve its innovation performance generally and more specifically in innovation-based value creation that would positively impact on socio-economic development (Van Jaarsveld, 2015).

The Global Innovation Index compares the innovation performance of countries through an Innovation Efficiency Ratio that measures the conversion of five input factors and 15 sub-factors into two output factors with six sub-factors. The Global Innovation Index (Insead, 2011) ranked South Africa 51st in 125 countries for its innovation eco-system and 59th for its innovation efficiency, including innovation capability, which is defined as the ability to exploit new and incremental technological combinations (Insead, 2011:x1). The Global Innovation Index released in 2015 places South Africa's innovation eco-system 60th out of 141 countries and shows that its innovation efficiency had dropped to 94th out of 141 countries (Insead, WIPO & Cornell University, 2015).

According to The Global Innovation Index, innovation is recognised as a central driver of economic growth and development, and innovation-driven growth is increasingly being achieved by developing countries (Insead, WIPO & Cornell University, 2015).

Innovation is a strategic priority for South African businesses, with 91 percent of South African respondents reporting that innovation is a strategic priority for their business (General Electric Company, 2013). South Africa's executives prioritised certain intentions to strengthen their innovation, such as declaring collaborative innovation as the way forward (94%), understanding customers and anticipating market evolutions (86%), employing innovative people (80%) and creating an environment conducive to innovation (77%) (General Electric Company, 2013).

Companies and countries, that have prioritised technology innovation as driver of economic success and growth, and allocated funds and resources for this activity, have outperformed those that did not (Thomson Reuters, 2016). Technology innovation, however, cannot be easily "packaged and transferred across regions or firms", and their ability to innovate is often shaped by macro-economic issues, national systems of innovation, their power and market position within international value chains, capability and business processes of the firms involved and their ability to identify and exploit external sources of innovation, especially international networks (Tidd & Bessant, 2011:84-85). There are advantages for emerging economies in having access to global technology platforms to establish new products and processes and being connected to global knowledge networks to be aware of, absorb and trigger new innovation. Emerging economies are fast becoming attractive sources of innovation. Tidd and Bessant (2011:88) estimated that over 20 000 multi-national corporations originated from emerging economies and that firms from the BRIC-economies (Brazil, Russia, India and China) in the Financial Times 500 list have quadrupled between 2006 and 2008. South Africa, who has joined the BRICS-economies, is thus systemically linked to global developments in technology and should be aware of the trends. From being a net importer of technology, Africa is starting to see technology being developed in Africa and being used to solve Africa's problems. According to one of the most successful chief executive officers (CEOs) in Africa (Nxasana, 2013), we need to find opportunities amidst the noise and the chaos in the world.

The 2014-2015 Global Competitiveness Report showed that South Africa's performance had dropped from position 62 to 66 out of 144 countries on technological readiness and from 39 to 43 on innovation. Innovation and particularly technology innovation need attention because globally knowledge creation and the application of that knowledge in creating new products and services are becoming significant contributors to the economic performance of the country (Van Jaarsveld, 2014).

At a firm level the histories of firms in technology-based industries suggest that there are no correct answers on how best to engage in global R&D that tend to shape future value creation technologies (Hoque, 2015; Tidd & Bessant, 2011).

A leading scenario planner, Clem Sunter (2013), believes that the entrepreneurial sector will increasingly become the job creators, rather than formal industry players who operate in the global economy, which is experiencing difficult times. Wits Business School hosted a public lecture by Dr Brian Armstrong, chief commercial officer of Telkom, in which he shared his views that digital technology has value in as much as it addresses disruption, optimisation, integration, humanisation, putting information to work and the need for leaders to ensure a supportive eco-system (Armstrong, 2016). Another executive-level technology innovation leader also claimed that innovation is not just about technology and cannot happen in a vacuum, as it requires catalysts and game changers in a larger community. He emphasised the importance of trust between players who work together to use technology to advance goals (Whitehurst, 2014).

This interconnectedness is captured in a statement at an innovation conference by South Africa's former minister in the Presidency and head of the National Planning Commission:

> *South Africans have to realise that the Bold & the Beautiful is not the blueprint for a successful future… in mimicry (of the television soap opera), we fail to understand: if we all were to live at that level of wealth, the planet would implode... Instead, a radical shake-up in the way the world works is needed to deliver progress on its wicked problems, including socio-economic inequality, climate change, the chronic burden of disease, and corporate corruption. This includes moving away from linear thought processes – 'last century's thinking' towards a systems approach. One of the biggest challenges that confront us is that every part of the decision-making that we need to deal with our challenges, can't be done on a linear basis (Manual, 2013).*

Beyleveld (2008:19) proposed that leadership excellence in South Africa should be understood within the context of its social environment, the socio-culture and family upbringing of leaders, and claims "that these leaders' social language patterning, values, beliefs and experiences of a post-*apartheid* South Africa... shape their meanings or social constructions".

In the context presented, technology innovation leaders or leaders in technology innovation, as referred to on accasions to distinguish the unit of measure, in South Africa, appear to be inextricably linked with both innovation with socio-economic outcomes, and innovation with international competitiveness as outcomes.

1.4.2. South Africa migrating to a knowledge economy

The relatively-new Department of Science and Technology (DST) (RSA, 2007) has taken the lead to position South Africa in the knowledge-based economy through its national Ten-Year Innovation Plan (TYIP). This plan includes a range of targets for 2018, such as the following extracts from Table 1.4:

- Achieve economic growth attributable to technical progress of 30 percent.
- Increase the proportion of firms using technology to innovate to above 50 percent
- Achieve high- and medium-tech exports/services at 55 percent of all exports/services.

The technology innovation leader operating from South Africa may be positively or negatively affected by these developments, which reiterates the significance of views expressed in the previous section, that technology innovation and its outcomes may be inextricable linked to and influenced by the innovation agendas of others.

1.4.2.1. The national innovation agenda – Department of Science and Technology 2018

Table 1.4 conveys the abovementioned, as well as additional measures related to South Africa's envisaged migration to a knowledge economy, as formulated in 2007 (Republic of South Africa, 2007).

Table 1.4: DST Ten-Year Innovation Plan for South Africa in the knowledge economy

Measure	2018
Economic growth attributable to technical progress *(10% in 2002)*	30%
National income derived from knowledge-based industries	>50%
Proportion of workforce employed in knowledge-based jobs	>50%
Proportion of firms using technology to innovate	>50%
GERD/GDP (0.87 in 2004; short-term 2008 target was 1%)	2%
Global share of research outputs *(0.5% in 2002)*	1%
High- and medium-tech exports/services as a percentage of all exports/services *(30% in 2002)*	55%

Source: Republic of South Africa, 2007.

In his 2013 New Year message to staff and stakeholders, the Director General of the DST, the leading department for South Africa's 2018 Ten-Year Innovation Plan, Dr Phil Mjwara (2013; RSA, 2013a) emphasised the following:

- We must deepen the efficacy of our initiatives to improve human capital development (including research and innovation competence);
- We must continue supporting master's and PhD students and ensure that the number of knowledge outputs grows (including innovation outputs and outcomes).
- We must strengthen our drive to facilitate the conversion of research ideas into commercialised products.

1.4.2.2. South African Research Chairs Initiative objectives

The South African Research Chairs Initiative (SARChI) was introduced by the Department of Science and Technology in 2006 and is managed by the National Research Foundation (NRF) to strengthen the research and innovation capacity of public universities to produce higher numbers of highly-skilled individuals, particularly in science, engineering and technology to achieve the goals of "an equitable, sustainable, and inclusive growth path that brings decent work and sustainable livelihoods, education, health, safe and secure communities, and rural development" (NRF, 2011:6). The SARChI aims to:

- Address the scientific leadership development needs in the universities;
- Forge new public-private partnerships to give South African universities and industry a competitive edge;
- Improve South Africa's international research and innovation competitiveness while responding to social and economic challenges of the country;
- Strengthen and improve research and innovation capacity of universities for producing high quality postgraduate students, research, and innovation outputs.

While some progress has been made towards achievement of the stated targets, the general performance to date has not met the targets and leadership development focuses mostly on the building of scientific capacity, rather than technological innovation:

- South Africa ranks 51st in 125 countries for its innovation eco-system and 59th for innovation efficiency (ability to exploit new and incremental technology) (Insead, 2011).
- South Africa has a growing trade deficit in high-technology (NACI, 2013).

1.4.2.3. NACI innovation performance indicators for South Africa

The ability to innovate has become mission critical for organisations that have to differentiate themselves from competitors. Technology innovation in particular is happening at such a pace and magnitude that it has become a driver of innovation and for innovation. The innovation-related indicators, covered in a 2003 to 2012 review period by the National Advisory Council on Innovation (NACI) (2013:4-5), show improvements in the number of publications and PhDs in science, engineering and technology (SET) awarded, as well as South African patents granted. Over the same period a decline in gross domestic product (GDP) per capita growth was reported as indicated in Table 1.5:

Table 1.5: Innovation indicators for South Africa by NACI

Indicators	2008	2009	2010	2011	2012	% change 2011 to 2012 or recent years
Number of publications in ISI journals	6949	7629	8155	9437	9793	3.8
SET PhDs awarded	575	704	730	854	985	15
SA patents granted in United States Patent and Trademark Office (USPTO)	91	93	116	123		6
Real GDP per capita growth (constant 2000 prices)	2.5	-2.6	1.7	2.2	1.3	-0.9

Source: NACI, 2013:4-5.

As a leading economist and project leader of the above report, Dr Azar Jamine (NACI, 2013:2) described the set of indicators in the report as follows:

> *[The indicators are] critical in assessing the impact of this strategy [National Research and Development Strategy (NRDS)] on South African knowledge generation capacity and the progress achieved in positioning science-based technology to improve quality of life and economic growth. In addition, it is important to monitor these indicators as we are halfway through the Ten-Year Innovation Plan (TYIP), which is key in positioning South Africa as a knowledge-based economy ... In order to give the indicators some scale of comparison, we benchmark the South African NSI against the BRICS countries and Japan, the United Kingdom and the United States. BRICS*

countries are useful for the comparison of scale-adjusted science, engineering and innovation indicators as these countries share economic and social challenges associated with emerging economies. The three developed countries serve as a benchmark for well-organised innovation systems.

The indicator report includes a section on imports and exports (NACI, 2013:22), emphasising a growing trade deficit in South Africa's high-technology manufacturing industry. The rates of trade deficit growth differed for various industries, with the highest growth occurring in the electronics sector at an average of 14.5 percent, followed by the pharmaceuticals sector (12.7%), scientific instruments (11.0%), office, accounting and computing machinery (10.7%) and aerospace sectors (3.5%).

The indicator report also includes sections on trends in awarding doctoral degrees and the establishment of research chairs (NACI, 2013:22-23) as conveyed in Table 1.6 and Table 1.7 below. While it would be nonsensical to argue that improving availability of SET and other doctorates would not contribute to innovation, the report is silent on any linkages between the reported growth in doctorates and the earlier reported growing trade deficit in technology.

Table 1.6: Doctoral degrees awarded by South African public universities

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
SET	522	499	561	522	590	575	704	730	854	985
Total	1 052	1 105	1 189	1 100	1 274	1 182	1 380	1 421	1 576	1 878

Source: NACI 2013:22-23.

Table 1.7: South African Research Chairs

Status	2007/08	2008/09	2009/10	2010/11	2011/12
Operational Chairs	34	69	79	87	88
Awarded Chairs	82	92	92	92	154

Source: NACI, 2013:22-23.

While the SARChI aim is reported to have 500 research chairs by 2018, the target of 210 research chairs by 2010 was missed as in the 2011/12 financial year there were only 88 operational and 154 awarded research chairs (NACI, 2013:22).

Two other sections covered by the abovementioned indicator report include the South African Human Development Index (HDI) and wealth creation by the technology intensive manufacturing sector. HDI is growing yearly although the average annual percent growth between 2000 and 2012 was a mere 0.11 percent, which is "much lower than most BRICS countries, with India seeing relatively the highest growth of 1.5 percent, followed by China (1.42%), Russia (0.84%) and Brazil (0.73%). For the same period, the medium human development countries (the category into which South Africa falls) experienced an annual growth of 1.29 percent, while

Sub-Saharan Africa had an average annual growth of 1.34 percent. In the year 2012, South Africa ranked 121st out of more than 200 countries. Brazil, Russia, India and China were ranked 85th, 55th, 136th and 101st respectively (NACI, 2013: 33).

Wealth creation by the technology-intensive manufacturing sector came mainly from turnover and value addition in medium- and low-technology-intensive industries, with a contribution of 41.6 percent and 38.2 percent respectively, albeit at a very low profit margin of 4.3 percent, which is the lowest in these industries. The high-technology sector showed the highest profit margin of 6.3 percent, while the largest contribution in turnover, value-added and profit margin was made by the pharmaceuticals industry. Pharmaceutical manufacturing had the highest profit margin in the South African manufacturing industry (11.0%), followed by recycling and other manufacturing (10.1%), non-electrical machinery (7.1%) and electrical machinery (6.8%). Industries that showed negative profit margins include shipbuilding (-3.9%) and aerospace (-1.1%) (NACI, 2013).

While several aspects relating to technological innovation leadership are being mentioned in the above report, the leadership competences required by those responsible for achieving successful technology innovation have not been included or acknowledged.

It appears, in the context of South Africa, that indicators of innovation success include both competitiveness and economic outcomes expected from technology innovation that the technology innovation leaders have responsibility for. In this study, both of these categories of outcome-indicators are accommodated as success indicators in shaping the focus of the study which is the identification of technology innovation leader competencies deemed to be required for successful technology innovation.

1.5. PROVISIONAL KNOWLEDGE GAP

Despite reported increases in scholarly publications, as well as innovation-related breakthroughs in thinking, knowledge and technologies over centuries, the formalised management of innovation represents a relatively new and complex area for management scholars (Lord, 2005:23; Shapiro, 2002:3; Ott, 2010:5). As an emerging field, a study of technology innovation leadership competencies needs to identify and deal with a range of challenges that more mature and established study fields may have conquered before. These relate to relatively low availability of scholarly material and shared terminology, which is still being developed for the study of complex phenomena, such as innovation (Malhotra, 2015).

Earlier discussions in Section 1.2.2 also emphasised the relative newness of innovation management studies and limited availability of knowledge pertaining to leader competencies. Drucker (1982) was one of the first management scholars to see innovation as a major new field for management. He pointed out that many publications shared this view, but failed to indicate which new behaviours would be required. Christensen (2002:33) described innovation as the new “science of success” and pointed out that much of the body of knowledge on management would be challenged to make way for new approaches and practices.

Organisations that lack competent innovation leaders may face serious problems in maintaining their relevance and differentiating advantage (Ashlubolagh, Shahrabi, Eftekhari, Ashlagi, Safdari & Abdolmaleki, 2013). McGrath (2016:1) reported that 94 percent of executives “...who were not pleased with how their innovation process was going had no idea what the problem was”.

Leaders are expected to lead organisational responses during times of crisis and are typically seen by others as those able to think and act creatively in difficult situations (BusinessDictionary.com, 2013a). With limited availability of scholarly material on technology innovation leader competencies, popular management newsletters and magazine articles may feature people labelled as experts who share opinions that may lack underpinning scientific rigour. Popularisation of unfounded claims can harm innovation leadership practices, especially when they refer to research findings that are not adequately contextualised, for example “the map is not the territory”, “the alchemy of innovation”, “eating yourself”, “tearing down pillars”, “beating the hierarchy” and “wagging the dog” (Grulke & Silber, 2001: x, 52, 75, 120, 133, 203). Thought leaders in innovation tend to be more pragmatic in their teachings, such as “Successful innovators acquire and accumulate technical resources and managerial capabilities over time...” and innovation in real life does not conform neatly to simple representation (Tidd & Bessant, 2013:88).

Current instruments for measuring what is to be detected, observed and analysed in the innovation economy are still mostly rooted in industrial management paradigms that may not acknowledge and integrate the dynamics of the innovation economy (Business Week, 2004). Tools and frameworks derived from research that assumes a stable and easily defined world where profound contextual changes are taking place “...just lose their relevance – they become actively misleading” (Jacobides, cited in McKinsey Insights, 2014a). Jacobides views such tools and frameworks as “...abstractions from reality that illuminate and identify some features and causal relations while simplifying or omitting others”. Wilson from Unilever, a multi-national corporation, claims that frameworks emerge mainly from books, which makes it seem more of a literary than a scientific process. “What people in my position want to know is which techniques are scientifically proven, so we can discard the rest” (Wilson, cited in McKinsey Insights, 2014a).

Theories provide plausible explanations of observed regularities (Bryman & Bell, 2011). A sound theoretical framework is required for reviewing literature, guide research and serve as a basis for developing new theories as contributions to the knowledge base (Malhotra, 2015). This study approached theory development by considering available theories pertaining to the study field, including theories and concepts from related disciplines in the qualitative phase, added perspectives from triangulated research data and subjected the emerging theory to empirical testing, as suggested by Malhotra (2015). Three disciplines appear to be active in producing scholarly contributions to the innovation body of knowledge on leader competencies required for successful technology innovation, namely: marketing, psychology and engineering. It may be argued that marketing places the customer at the centre; psychology places the individual at the centre; and engineering offers problem-solving and other process capabilities. Theoretical perspectives from other domains are also considered in Chapter 3 which focuses on theoretical foundations in literature for use in this study.

1.6. STUDY RATIONALE SUMMARISED

Preceding discussions contextualised the growing significance of innovation and technology in society and related challenges for management and established management practices generally and for technology innovation leaders in particular. Having also exposed knowledge gaps, this study investigates the competencies of technology innovation leaders that are deemed to be required for successful technology innovation. This study aims to contribute scientifically-derived knowledge from which identified entities are likely to derive benefit. It should be clear from the preceding discussions that South African leaders in business, government and innovation practices acknowledge that technology innovation is a high priority in the country for socio-economic and strategic reasons. Several international reports reveal that South Africa has been slipping backwards on innovation rankings.

The rationale for this study can thus be summarised as follows:

- Technological innovation as a major driver of socio-economic development is widely acknowledged in policy and strategy declarations in South Africa (Department of Science and Technology, 2007; RSA, 2007). Technological innovation is thus associated with economic growth (Kakaes, 2012; Muller, 2013; Solow, 1974).
- Societal challenges and greater individual and institutional innovation capabilities brought about by technology innovation are causing technology innovation leaders to acknowledge innovation as a strategic priority. Technology innovation is seen as a solution (Lochner, 2011; Van Jaarsveld, 2015).
- While some claim to have experienced innovation success (Lafley & Charan, 2008:3), most organisations still have to re-examine and adjust their capabilities to compete in the changing and complex market place (Nel & Beudeker, 2011:35). While pursuing innovation success, leaders may find their current practices to be inappropriate (Birkinshaw, 2001; Metcalf, 2014).
- Technology innovation leaders wanting to respond successfully to innovation challenges and opportunities require greater clarity on what being competent entails. Leaders who feel inadequate or incompetent may fail to reach important innovation targets (Harvey, Cohendet, Simon & Borzillo, 2015).

- Of the South African managers surveyed, 47 percent did not have innovation objectives in their business plans, and 32 percent believed that they did not have the right skills, processes and environment for achieving innovation success (Steyn & Bell, 2016:10).
- For leaders who wish to develop their competencies, it could be argued that the innovation body of knowledge should provide clarity on the leader skills required for successful technology innovation. From preceding discussions, it should be clear that such knowledge is currently not available in formats that have survived the rigour of scientific enquiry (Barsh *et al.*; 2008; Hill *et al.,* 2014; Kaskhedikar *et al.,* 2013; Kets de Vries, 2001; MacDonald, 2010; Phapruke, 2011).

Against this background this study has a specific focus and contribution to make by identifying the technology innovation leader competencies deemed to be required for successful technology innovation. The above points collectively and separately present a compelling case to address the identified knowledge gap. The envisaged research contribution would bring greater awareness and understanding of underpinning competencies to those leading technology innovations, while South Africa and its socio-economic development may benefit from the envisaged improvement of technology innovation performance.

Successful execution of this study should contribute to the understanding of relationships between technology innovation leader competencies and innovation success from which practitioners and scholars would benefit, as indicated in Table 1.8.

Table 1.8: Summary of potential benefits for different stakeholders

Stakeholder	Envisaged benefits from new insights
Technology innovation leaders	Benchmarked information for directed personal and professional development towards successful technology innovation.
South African National System of Innovation (NSI)	Government: enhanced understanding of requirements for delivery on strategic innovation imperatives, such as the DST TYIP. Business: enhanced competitiveness from innovation, such as measured by the Competitiveness Report produced by the World Economic Forum.
Academia in technology innovation	Enhanced relevance of research, learning and development as well as community outreach activities derived from clearer focus on leading technology innovation.
Science councils	Focused career, professional and personal development of scientists aspiring for leadership positions.
Executives responsible for technological innovation	Foundational reference base for customised application in support of organisational business objectives. Goal directed and relevant investment of time and resources into leadership development programmes.
HR and learning and development practitioners/service providers	More informed curriculum design and learning process choices. Measurement tools to assess impact of learning and development. Structuring of mentoring and coaching relationships and protocols. Benchmarking guidelines.

1.7. DELIMITATIONS, RESEARCH SCOPE AND EXCLUSIONS

The study of innovation leadership as concept is still relatively new and so is technology innovation leadership (Hill, 2014). The formalised management of innovation represents a relatively new and complex area for management scholars (Lord, 2005:23; Ott, 2010:5; Shapiro, 2002:3) who may encounter a low availability of scholarly material and terminology typically required for the study of complex phenomena such as innovation (Malhotra, 2015).

In light of these challenges, this study aims to focus on the identification of technology innovation leadership competencies deemed to be required for successful technology innovation. While the scope of the study is specific it had to be approached from a sufficiently broad perspective to cover the innovation value chain or innovation process (Hansen & Birkinshaw, 2007) in pursuit of successful technology innovation.

This study excludes the following:

- Innovation leadership has been attracting scholarly interest resulting in new innovation leadership typologies being proposed at organisational, group, team and even networking levels (Gliddon & Rothwell, 2016) and these are not included in this study.
- Opinions on innovation leader competencies appear in the popular press and social media which may not acknowledge or practice scientific rigour in screening and publishing its content. Such materials may only be considered when it can be related to successful technology innovation or when scholarly sources fail to provide perspectives for consideration.
- Competencies are defined in Chapter 3 as “sets of behaviours that are instrumental in the delivery of desired results” rather than “personal attributes that have no behavioural expression within the work environment” (Bartram, 2006:2).
- Organisational variables, such as budgets, personality profiles of the leaders or culture and climate as enablers for innovation (Trompenaars, 2011:1), are not addressed directly in the study. This study also does not include analyses of organisational or environmental characteristics linked to innovation and the competencies identified in the study were not specifically linked to particular industries or organisations (Gliddon, 2006:10). No data was gathered specifically on these factors.

1.8. OUTLAY OF CHAPTERS

Table 1.9 provides an overview of the chapters in this thesis, their flow and their key messages.

Table 1.9: Research conversation across thesis chapters

Chapter	Chapter elements and key messages
Chapter 1: Introduction and study rationale	• Increasing significance of innovation and technology innovation within a systemic societal context. Innovation is seen as a strategic priority and technology innovation central because it influences economic growth. • Innovation consequences for leaders. Organisations appoint innovation leaders to lead innovation. Innovation may require new leadership competencies. Technology innovation leadership competencies for successful technology innovation are not known. • South African technology innovation in global context. • Study rationale. New knowledge may fill knowledge gaps to bring about improved technology innovation. • Thesis scope and reseach exclusions. • Provisional conceptual model
Chapter 2: Researcher experiences that shaped the research questions	• Curiosity as driver of scientific progress • Researcher experience and its consequences in qualitative research. • Defining moments during the researcher's work in the field and with technology innovation leaders. • Researcher challenges and observations on technology innovation leaders' achievements for reasons that have not been investigated. • Research questions informing the scientific enquiry and process.
Chapter 3: Theoretical foundations of the study	• Terminology • Existing concepts and theories are reviewed to refine the knowledge gap regarding competencies, innovation, innovation processes models, process competency perspectives, leadership and success theory to inform the identification of technology innovation leader competencies in a systemic rigorous manner. • Current innovation processes covered in literature tend to approach innovation as starting with an idea, followed by a linear series of sequential steps and culminating in the deployment or adoption of new technology. This notion is critically examined as basis for identifying leader competencies for technology innovation before proposing interim capability clusters for further exploration and validation. • A theoretical framework is presented to guide the study scope and choice of research methods for the research to be done, including terminology. • Theory perspectives are discussed to direct the study contribution.

Table 1.9: Research conversation across thesis chapters (continued)

Chapter	Chapter elements and key messages
Chapter 4: Research design and methodology	• The research scope for this study is linked to the research problems and questions. • The research philosophies underpinning this study are discussed. • Sequential exploratory design is justified as a research design. • The use of multiple sources of research data for triangulation of sources to distil concepts constructs and items for the measurement instrument. • The qualitative first research phase is presented together with its goal, and research methodology. • Competencies identification and population of research themes. • The quantitative second phase of the research is presented together with its goals and research and sampling methodology to source and analyse survey data for analysis and testing of the research hypothesis and theory development. • Development of measurement instrument and its validation. • Planning and execution of a pilot survey • Response rate parameters are discussed for the main survey. • Data analysis approaches are discussed together with theory development considerations, competency profile considerations and guiding thesis reporting principles. • Theoretical framework • Methodological framework
Chapter 5: Qualitative research phase results	• Research results from qualitative research sources are presented, including experts, case materials, practitioners and literature. • Results for both innovation process-based competencies and technology innovation leader competencies are presented and discussed. • Coding of research data is discussed as basis for competencies identification and population of interim capability clusters as research themes. • Conceptual constructs and their underpinning items are derived from triangulated research data through content analysis. • Emerging elements of a theory are discussed.
Chapter 6: Quantitative research phase results	• Pilot survey results and refinement of the measurement instrument for use in the main survey. • Survey response rates and results of the main survey are presented and discussed. • The demographic, descriptive and inferential statistics from analysis of the research data are presented and discussed. • The psychometric properties of the measurement instrument are presented and discussed. • The statistical model derived from the statistical analysis of the hypothesised model is presented and discussed. • Research data analyses are interpreted to reveal salient patterns identified.

Table 1.9: Research conversation across thesis chapters (continued)

Chapter	Chapter elements and key messages
Chapter 7: Summary, conclusion and recommendations	• Main insights relating to the technology innovation leader competencies identification are presented as progressive steps. • Claims are presented and linked to different phases of the research. • The contribution of this study towards theory, knowledge and process is discussed. • The broader significance of the findings is contextualised • A furure research agenda is proposed. • The study is concluded by linking the findings back to the research question and the expansion of the body of knowledge.

Having provided an outline of the chapters to follow, the following section discusses doctorates, an integrative philosophical framework and a provisional conceptual model to guide the study.

1.9. COMPONENTS OF DOCTORATENESS

Based on their analysis of examiners' thesis-related observations and feedback, Trafford and Leshem (2009:309) proposed a template for reviewing the doctorateness of research, as illustrated in Figure 1.4. 'Doctorateness' is referred to by Trafford and Leshem (2009:308) as a "jigsaw puzzle that can only be fully appreciated when all the components are present and fitted together", suggesting that critical research features are mutually interdependent in a network system of parts that have practical relationships within the thesis.

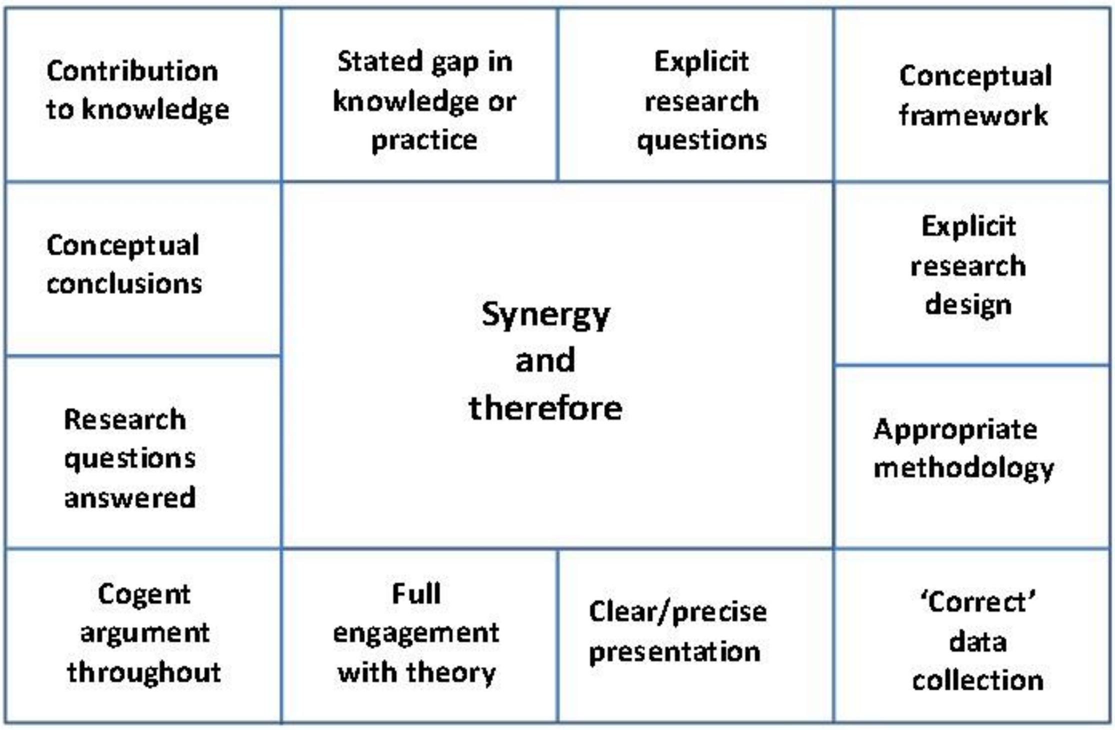


Figure 1.4: Components of 'doctorateness'

Source: Adapted from Trafford and Leshem, 2009.

Each of the components in Figure 1.4 is seen by Trafford and Leshem (2009:311) as portals or thresholds that candidates have to know about or for which they have to demonstrate their capability. In this thesis, each of these components has been addressed in their respective chapter sections, from which the following summary was compiled and is presented here in the introductory chapter to provide an early integrated '*doctorate'* view of the research.

The suggested starting point of doctoral research is a "…gap in knowledge, or professional practice, which is worthy of investigation" (Trafford & Leshem, 2009: 308). Reading and thinking, as well as drawing on personal experience, generate theoretical perspectives on the topic from which, at some stage in the thesis, a conceptual model emerges to guide the research design, the choice of methodology and the fieldwork methods for data collection (Trafford & Leshem, 2009:308).

- The stated gap in knowledge or practice in this study is presented as uncertainty perceived by technology innovation leaders about the leader competencies deemed to be required for successful technology innovation in an era of exponential scientific and technological advancement (Sections 1.3, 1.4, 1.5, 3.7, **3.9**).
- The explicit main question for this study was: "What are the leader competencies that are deemed to be required for successful technology innovation?" (Section 1.3, Table 2.1, Sections 2.6, 3.1, **4.2,** 4.3, 7.8).
- The conceptual model for this study is first presented as a provisional version in Section 1.10 and and revised in Section 3.1 to guide literature reviews and Section 3.9 to confirm the knowledge gap.
- The explicit research design for this study is a sequential exploratory design as discussed in Section 4.4.
- The appropriate methodology in this study was based on mixed methods from a qualitative and quantitative paradigm and anchored in a pragmatic paradigm (Section 4.4).
- "Correct" data collection consisted of qualitative research sources (experts, cases, workshops and literature) and quantitative research data was obtained through a measurement instrument used in a survey with respondents being identified through snowball sampling (Section 4.6 for qualitative and Section 4.7 for quantitative data).
- Clear/precise presentation in this thesis manifested in qualitative findings and quantitative results presented mainly in Chapter 5 and Chapter 6 respectively.
- The full engagement with theory in this study manifested in an integrative leadership model in Chapter 7.
- Cogent argument throughout is guided by the conceptual model.
- Research questions are answered (Sections 3.1, 4.2).
- Conceptual conclusions are drawn (Section 7.7).

- The contribution to knowledge from this study includes the identification and description of leader capabilities deemed to be required for successful technology innovation, their underpinning behaviours and a competency model presented in Chapter 7.

The above components are integrated through synergising and argumentation in the respective chapters and can be linked to an integrative philosophical framework in Figure 1.5, which was compiled by the researcher to provide a summarised visual map of how the thesis chapters, frameworks and research contents can be viewed from an integrated perspective.

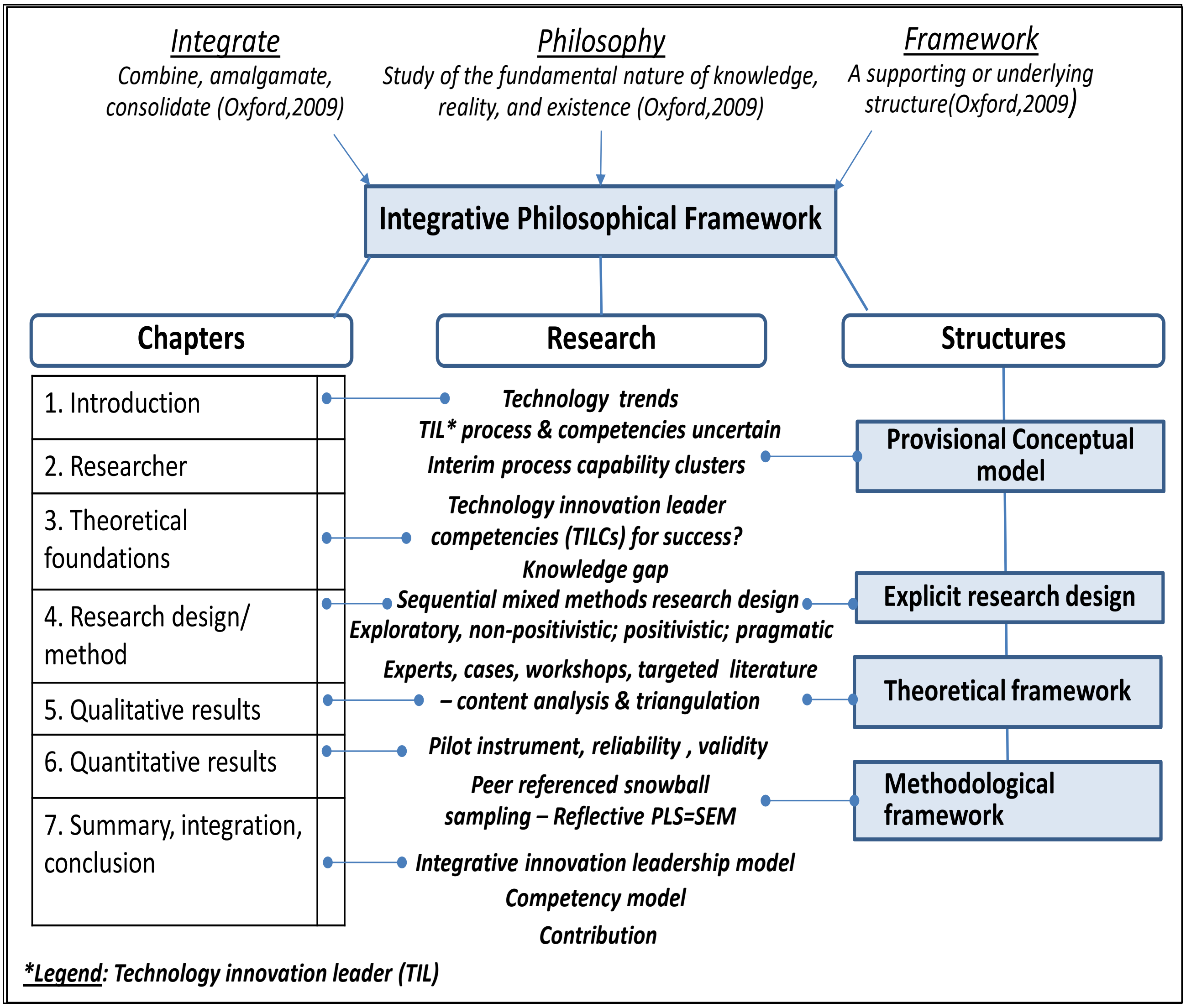


Figure 1.5: Integrative philosophical framework

The provisional conceptual model shown as one of the structures in Figure 1.5 is discussed next.

1.10. PROVISIONAL CONCEPTUAL MODEL

One of the frameworks in Figure 1.5, the provisional conceptual model, is a provisional version of the conceptual model presented in the literature discussion in Chapter 3. The conceptual model in Chapter 3 positions the empirical research in terms of other research, explains why the research is designed in a certain way, and allows for explanation and justification of conclusions through conceptually coherent arguments that contribute to knowledge (Leshem & Trafford, 2007:93).

The conceptual model can be seen as a bridge between paradigms that explains the research issue and the practice of investigating that issue, while giving meaning to the relationship between variables derived from the researcher's appreciation of reading, personal experience and reflection upon the theoretical positions towards the phenomena being investigated (Leshem & Trafford, 2007:99).

Different conceptual models may be conceptualised and applied throughout a study to demonstrate the researcher's ability to make flexible, purposeful use of frameworks to raise their thinking level from content to meta-levels of conceptualisation and answer questions (Leshem & Trafford, 2007:103). Conceptual models have to demonstrate unity within appropriate theories, provide direction to research design and accompanying fieldwork, and coherence between empirical observations and conceptual conclusions (Leshem & Trafford, 2007:101).

As a result of the squential mixed-methods research design of this study, the provisional conceptual model presented in Figure 1.6 is shown as a provisional perspective to indicate its assumptive composition during the early stages of this study. Incremental arguments during the flow of the thesis show the corresponding logic of the theoretical framework, innovation processes and leader competencies identification as well as the theoretical foundations from which the main research question is answered and new theory is proposed.

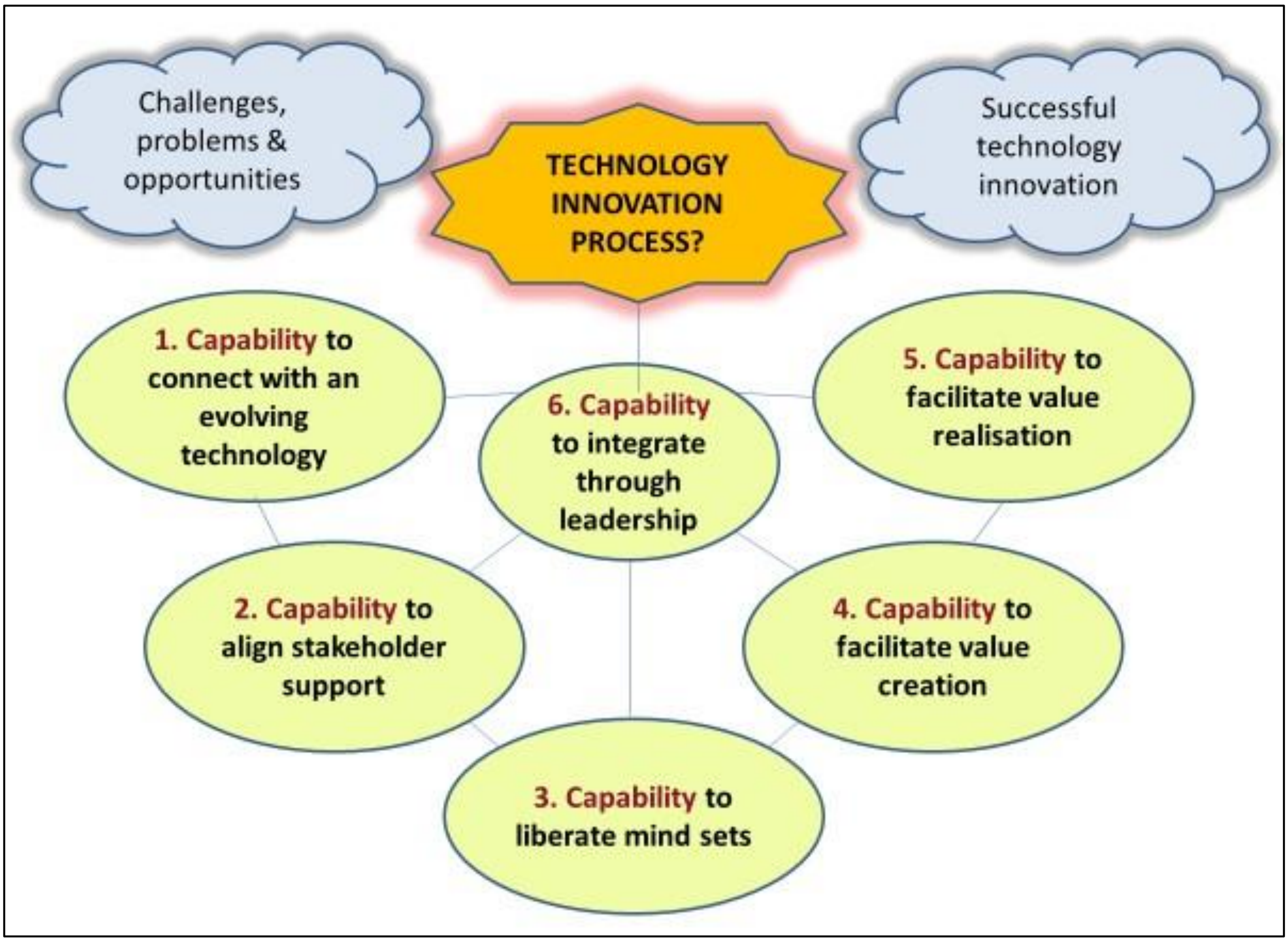


Figure 1.6: Provisional conceptual model

In the early research stages of this study, the researcher observed that innovation process and leader competencies may not have been connected in the current body of knowlegde to provide a plausible explanation of the technology innovation process of migrating from challenges, problems and opportunities, to successful technology innovation, and the leader competencies required across the whole process (Tidd & Bessant, 2013:21).

The capabilities shown in Figure 1.6 represent a tentative first view of capabilities that may be required across the innovation process, as derived from a decomposition of reviewed processes in Chapter 3. The provisional conceptual model presented in Figure 1.6 is used and updated throughout this thesis to guide and report on the content of the study at the end of each chapter.

1.11. CHAPTER CONCLUSION AND SYNTHESIS

This chapter emphasises the increasing significance of innovation and technology innovation within a systemic global and local societal context. That explains why innovation is seen as a strategic priority with technology innovation being central because of its anticipated influence on competitiveness and economic growth. As the knowledge economy is giving knowledge workers entry into information and resources for technology innovation, there is increasing scholarly interest in managing innovation. Most importantly, there is a need to fill knowledge gaps pertaining to technology innovation leader competencies deemed to be required for successful technology innovation in organisational settings. Organisations appoint technology innovation leaders to bring about successful technology innovation. Some of these leaders acknowledge that they may require new leader competencies. Unfortunately for them, scholarly knowledge on technology innovation leader competencies required for successful technology innovation is not readily accessible yet, which provides a compelling case for conducting this study.

Since this research had not been done before and knowledge gaps were becoming more visible, it became apparent that a knowledge base that could inform decisions on appointment and performance of innovation leaders is lacking. Those involved in appointing leaders and supporting them to achieve success, have the opportunity to respond to the emerging development needs of innovation leaders (Mintzberg, 2004:5). According to Von Stamm (2012), we need more MBIs (Masters of Business Innovation), rather than more MBAs (Masters of Business Administration).

As a synthesis of this first chapter the contextual background to the study provides a compelling case for investigating the competencies required for technology innovation leaders at South African -governed knowledge intensive organisations forming part of the National System of Innovation (NSI). An integrative philosophical framework was compiled by the researcher to convery a golden thread to readers on how the research was conceptualised and executed to yield a contribution to the knowledge base. A provisional conceptual model is presented to specify innovation process and leader competencies being conceptualised as an interim set of capability clusters derived from a decomposition of innovation processes reviewed. The integrative philosophical framework in Figure 1.5 indicates how chapters, structures and research content will be integrated through-out the study to answer to the research question which would provide new knowledge to technology innovation leaders to emulate and apply in pursuit of improved performance in challenging times.

This introductory chapter explained that this study focusses on the identification of technology innovation leader competencies deemed to be required for successful technology innovation, and that such knowledge is important in light of uncertainty expressed by such leaders. This chapter also presented a provisional conceptual model which proposes innovation process and leader competencies as two interrelated study fields, and is included in an integrative philosophical framework that illustrates how thesis chapters, research frameworks and content interrelate, and thus meet the objectives of a thesis introduction (Bryman & Bell, 201:681).

CHAPTER 2

RESEARCHER EXPERIENCES THAT SHAPED THE RESEARCH QUESTIONS

2.1. CHAPTER INTRODUCTION

What are the technology innovation leader competencies deemed to be required for successful technology innovation? In conducting research aimed at answering this research question, researcher bias is a possible source of research error to be acknowledged and managed throughout the research process (Babbie & Mouton, 2008; Bryman & Bell, 2011; Mouton, 2003). Awareness of possible sources of error and the means of "...avoiding or reducing error lies at the heart of good scholarship" (Mouton, 2003:110). This chapter is included in the thesis for three reasons. Firstly, this chapter reveals personal experiences of the researcher over time that gave rise to the curiosity of the researcher to explore technology innovation leader competencies from a scientific research perspective. Secondly this chapter acknowledges researcher awareness of potential personal bias throughout the chapter. Thirdly this chapter conveys measures taken by the researcher to avoid or minimise researcher bias as a reality in this study.

Figure 2.1 summarises this chapter that starts with a scholarly perspective on curiosity as a driver of knowledge generation, followed by a reflection on the role of experience in qualitative research, a summarised selection of "defining moments", a discussion on bias-related research challenges and compensating mechanisms as well as a chapter concluding section.

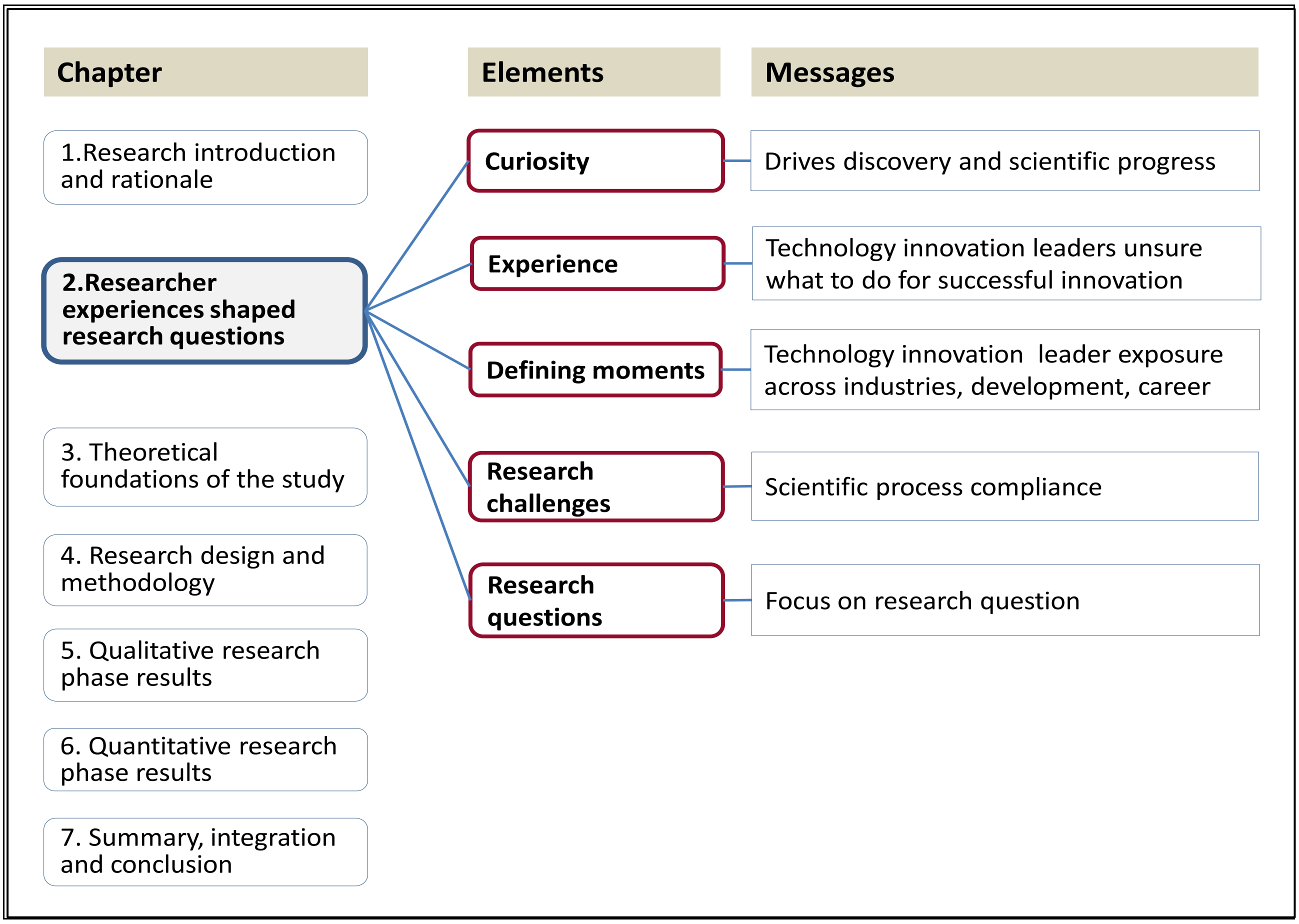


Figure 2.1: Thesis map of Chapter 2

2.2. CURIOSITY-DRIVEN KNOWLEDGE GENERATION IN SCIENCE

2.2.1. Overview

'Curiosity' is defined as a strong desire to know or learn something (Oxford Dictionary, 2009). Curiosity was a major driving factor in the technology contributions of Leonardo da Vinci centuries ago and is still acknowledged as a major factor in stimulating new insights and innovation (Gelb, 2004; Giddon, 2006; Kanter, 1999; Swart, 2013).

Through digital media curious people have easy access to knowledge sources and can contribute to new knowledge creation. Information technology innovations during the 1990s influenced both knowledge production and application practices by allowing "...closer interaction between scientific, technological and industrial modes of knowledge production, by the weakening of disciplinary and institutional boundaries, by the emergence of more or less transient clusters of experts" (Gibbons, Limoges, Nowotny, Schwartzman, Scott & Trow, 1994:68). As a result, "...contemporary science cannot remain easily within the confines of university departments of academic centres" because of new institutional arrangements, linking government, industry, universities and private consulting groups in different ways to produce and use knowledge in resourceful creative ways (Gibbons *et al.*, 1994:76).

The curiosity of scientists to resolve scientific challenges has remained an important driver of research to acquire new knowledge and expand mankind's knowledge through improved understanding of the underlying phenomena and observable facts. The "...processes of obtaining knowledge and applying knowledge for innovation" are main scientific and technological activities in China's universities, whose R&D activities focus on creativeness, originality, and producing new knowledge or technology (Tang, 2008:32). The translation of science into action remains a challenging boundary which can be crossed if the knowledge is seen as being relevant to decision-making bodies, regarded as authoritative, believable and trusted, as well being developed in a way that considers the values and perspectives of all actors (Cook, Mascia, Schwartz, Possingham & Fuller, 2013). While scientific credibility is important in management-relevant science, the pursuit of scientific credibility alone can compromise the salience and legitimacy of information in the eyes of decision-makers and thus cause a knowledge-action boundary (Cook *et al.,* 2013). Cook *et al.* (2013) described a 'boundary scientist' as a scientist seeking relevance on both sides of the knowledge-action boundary, meaning that their knowledge contribution should be both scientifically and managerially relevant and timely, as envisaged for this study.

2.2.2. Curiosity drivers of this study

The points raised in the previous section are relevant to the researcher's quest for understanding technology innovation leader competencies required for successful technology innovation in two ways.

Firstly, the curiosity of Leonardo da Vinci resonates with the researcher, whose curiosity is anchored in unresolved questions encountered across an exceptionally diverse range of career experiences that included knowledge generation and application through improved ICT, development and commercialisation of science-based knowledge offerings, and a "boundary scientist" seeking relevance on both sides of the knowledge-action boundary (Cook *et al.,* 2013) by:

- Serving in senior management and functional specialist positions in human resources (HR), business analysis, marketing, R&D, business development, commercialisation of scientific and technology breakthroughs, strategic human capital development interventions and academic duties in higher education.
- Working in multiple sectors, namely: automotive, ICT, building and construction, multi-disciplinary research and technological innovation value chains in the public and private sectors.
- Facilitating innovation strategy formulation, capability building, performance and leadership processes.

Secondly, the researcher is curious to understand the implications of innovation as an emerging management science for the competencies of technology innovation leaders. In 2002, innovation thought leader, Clayton Christensen, called innovation the "new science of success", claiming that leaders with a better understanding of cause and effect relations in innovation would become more successful in achieving desired levels of innovation, rather than relying on out-dated models (Christensen, 2002:33). The researcher has had many opportunities to observe Christensen's foresight being turned into reality and to question assumptions because of a rather unique series of career exposures that influenced his own thinking and understanding of technology innovation and the requirements for success. Much of the researcher's interest in innovation comes from having worked with highly-successful to less-successful innovation leaders in general and technology innovation leaders in particular. These include individuals who came up with new ways of creating value in turbulent landscapes, while others would find reasons not to innovate. Some never claimed the spotlight and refused to be driven by ego, but have left a legacy that keeps on inspiring others to provide new solutions through technology innovation.

The researcher acknowledges that his interest in the conduct of innovation leaders was strongly influenced by a favourite quotation of a dear friend and mentor; someone who has pioneered innovation in academic circles, industry and the socio-economic dynamics of the region:

> *All men dream: but not equally. Those who dream by night in the dusty recesses of their minds wake in the day to find that all was vanity, but the dreamers of the day are dangerous men, for they may act their dreams with open eyes, to make it possible.* (T.E. Lawrence, 1922)

Based on hindsight and reflection, the researcher believes that the competences of technology innovation leaders can have significant influence and may even be a greater catalyst for successful or failed technology innovation than any other influence.

Working in an organisation established to conduct multi-disciplinary research and technology innovation across sectors, exposed the researcher to successful and less successful technology innovation leaders. From initial business unit level responsibility for marketing, business development and commercialisation of science based inventions, the researcher became involved in the innovation value streams of all business units and increasingly played the role of facilitator of innovation processes, strategy formulation, capacity development, value creation and delivery. The researcher also held the responsibility for innovation capacity building, which included leadership development and research and innovation core skills for scientists, engineers, technologists and functional specialists. He developed an award-winning leader development programme that has had significant impact on the leaders' behaviours since. One of the studies conducted to understand the challenges and practices of leaders focused on the top performing technology innovation leaders of the organisation. The results of this in-house study came as a shock for senior management. While the dominant paradigm in leadership development at the time was fuelled by beliefs that a hero-type leadership orientation would work best for scientists, the findings showed that innovation leaders who achieved high growth levels over at least five years and also achieved high customer and staff satisfaction levels, were servant leaders who created opportunities for their people, appreciated and harnessed diversity and did not come from any one particular discipline.

Personal life experiences contributed to the researcher's notion that some leaders achieve near miracles in the technology innovation space, while others fail to adjust themselves, their people and their operations in a fast-changing technological innovation landscape. In trying to understand and capture the differences between the two, as well as the conditions that gave rise to these differences, the researcher has been searching for answers to, or at least a better understanding of many of the underlying questions.

Table 2.1 conveys a summary of researcher experiences and associated researcher-initiated questions of relevance to the research being undertaken in this study.

Table 2.1: Researcher experiences that initiated pre-research questions

Researcher experience	Unresolved questions
Chemistry set for birthday	Which leader behaviours influence others to become excited about and explore new technology possibilities?
Automotive industry as HR manager	Which behaviours of Iacocca made the success of the Ford Mustang possible? Which behaviours of our leaders persuaded design teams from different countries to work together on our plant upgrade?
ICT sector as business systems analyst, marketing manager, and capacity builder	Which behaviours of leaders made it possible for some teams to outperform others while serving the same client with the same technical expertise?
MBA studies and research into strategy formulation practices	What influence did leader behaviours have on creating enterprises that performed better than their competitors in the same markets and with similar resources?
Young researchers' symposium in Canada on the future of research	Which leader behaviours enable innovators to innovate for a particular context and adapt a narrow or broader technology innovation focus?
Top performer interviews as marketing and business development manager	Top performing leaders came from various technical and non-technical backgrounds, ascribed their success to their people rather than themselves and envisaged success beforehand. Can we create an environment in which other leaders would emulate our successful leaders? How can “kaleidoscope thinking” be made popular as leadership mechanism during innovation?
International technology innovation facilitation and benchmarking	Which leader behaviours made the following practices acceptable practices? Finland – world leadership in selected technologies? India – knowledge sharing? France – alignment of SET players around technology innovation priorities? Germany – longer-term research capability? Malaysia – learning from others to advance national innovation programmes? Washington DC – which leader behaviours resulted in the displays at the air and space museum and what has to happen for a leader to acknowledge that imagination is more important than knowledge?
Strategic human capital development assignment	Which leader behaviours enabled some SET teams to express desired futures, solicit stakeholders support, attract talent and achieve capacity building targets in collaboration with educators and beneficiaries?
University teaching	Which leader behaviours of faculty enable collaborative knowledge generation technology innovation?
Doctoral research	Which leader behaviours enabled subject domain experts to become successful in technology innovation?

The individual pre-research questions mentioned in Table 2.1 stemmed from the researcher's curiosity and are not all addressed in this study, which focuses on the main research question and research sub-questions presented in Section 2.7, Table 3.1 and Section 4.2.2.

2.3. THE ROLE OF RESEARCHER EXPERIENCE IN QUALITATIVE RESEARCH

A researcher's personal experience and practice can form useful relationships with concepts and theory in the process of meaning-making in qualitative research. Conscious engagement of the researcher with him/herself in a critical reflection process to develop new knowledge is important in "…the dynamic spiral of meaning-making when developing a conceptual model" (Schurink, 2012:1). Schurink (2012) emphasised that concepts, hunches, assumptions, statements, definitions and hypotheses are building blocks that are only as plausible and valuable as their foundations. Therefore, reflection is needed on how the researcher's own ontological, epistemological and methodological assumptions influence meaning-making because:

- All concepts are normative since they evoke positive and negative reactions from those they describe, as well as the researchers who use them;
- It is not difficult to understand the core meaning of a concept, but is it difficult to separate a concept from its context; and
- Most concepts come from prior assumptions and are embedded in other concepts.

> *Qualitative research is an interdisciplinary, transdisciplinary, and sometimes counterdisciplinary field. It crosscuts the humanities, the social sciences, and the physical sciences. Qualitative research is many things at the same time. It is multi-paradigmatic in focus. Its practitioners are sensitive to the value of the multi-method approach. They are committed to the naturalistic perspective and to the interpretive understanding of human experience. At the same time, the field is inherently political and shaped by multiple ethical and political allegiances* (Denzin & Lincoln 2000:7, cited in Schurink, 2012:6).

It can be argued from the above discussion, that the relatively broad and diverse career experiences of the researcher of having worked in managerial and functional specialist positions across several sectors and industries may influence the meaning-making process being pursued in this study. By not acknowledging these influences, a researcher's work may be diluted to mere repetitions of existing concepts, rather than new knowledge creation.

> *…when the qualitative research process is removed from the network of the ontological, epistemological and other constitutive assumptions, all that is left is to regard the methods used as research strategies or techniques that can be taught like 'recipes' following specific steps. To make matters worse, through this, qualitative research could be reduced to nothing more than a situational problem-solving strategy.* (Schurink, 2012:7)

From a pragmatic perspective, it is thus important for the researcher to apply a well-conceptualised research design where reflection and data analysis form part of the total research process underpinning the researcher's meaning-making process (Schurink, 2012).

The researcher argues that this study allows for reflection and sense-making in the following ways:

- Including this chapter in the thesis to emphasise researcher awareness of researcher bias.
- Engaging other observers of the same instances when interpreting qualitative data, such as the case studies being included as research data after they had been verified by the former executive director(s) responsible for the areas in which the observations were made by the researcher.
- Following the qualitative research phase by a quantitative phase allows for robust testing of conceptual work done during the qualitative first phase.
- Conveying life stories openly and explaining to readers how personal accounts were produced. In this way, they make a methodological contribution to the body of scientific knowledge" (Schurink, 2012:13).

The next section conveys defining moments that may influence what Schurink (2012:9) described as the researcher entering:

> *…the spiral of meaning-making where his/her current level of knowledge, insight and understanding is deepened up to a point where conceptual saturation could take place. In the broadest sense of the word, all research is a systematic and rigorous 'study of a subject, to discover (new) information or reach a (new) understanding' that could contribute to the scientific body of knowledge.*

2.4. DEFINING MOMENTS

Defining moments are moments of insight derived from our "...ability to change our filter and look at things differently" and there is a "...sudden burst of clarity where there had previously been static... it's a-ha moment", "defining moments speak to the deeper underlying questions and struggles of our lives" (Schwartz, 2011:1-2). A fully-detailed account of the researcher's biography for qualitative analysis is not the focus of this study and will not be included in this thesis "...for reasons of length and also confidentiality". A selection of defining moments of relevance to this study, as summarised in Table 2.1, is thus presented to exemplify particular experiences deemed to have influenced the researcher's interest in the research topic (Taylor, 2012:396).

2.4.1. Chemistry set for my birthday

I often wish that my late grandfather was still with us to see how the first chemistry set that he had given me for my birthday had influenced my life orientation. He was a science and mathematics teacher in his early career stages and probably the first technology innovation leader to influence my thinking about new possibilities. While other school pupils played sports, engaged in teenage social activities and studied to do well in their academic score cards, my life was severely impacted by the discovery of new possibilities brought about by mixing things that I did not understand, but could enjoy when they produced smoke, smells, and many other things that I do not think grandpa had in mind when he gave me the box full of test tubes and powders.

When I enthusiastically shared my experiments with others, I discovered that people responded differently. While a few appreciated the fun, some thought it was boring, some could not associate any benefits with my endeavours and some had told their parents about my dangerous activities. It came as no surprise therefore, that my teacher wanted to see me after class to find out what exactly I was doing. I could not tell him that I was experimenting with fireworks and for the sake of all involved, I promised to behave by limiting my experiments to those listed in the user manual.

Unresolved question: “Why did my grandfather give me chemistry set when he could have given me a speech instead, and why did some of my school friends join our journey of discovery while others regarded this as a dangerous activity?”

2.4.2. Building vehicles from different countries

The automotive industry has been playing a pioneering role in technological innovation. From Henry Ford who focused on mass production to drastically improve productivity, this industry has remained a prominent user of new technologies becoming available, as well as pushing the boundaries for new technological innovations. The researcher recalls the liberating and energising influence of some leaders who declared the possibility of new technologically-enabled futures and causing it to happen, while other leaders cautioned against the risk and uncertainty, preferring to stay with convention and tradition and then ending up in situations where they were trapped and had run out of attractive options. The researcher recalls how some leaders had not only taken the lead in technology innovation matters, but also in reshaping the rules of the game, such as persuading different players in the value chain to work together by sharing their expertise and resources. Their people were happier, their customers were happier and their products performed better in a competitive marketplace. Other leaders preferred to operate from a base of established practices and when their landscapes changed, their default mode was to cut cost, centralise power, introducing more rules for people to meet and generally disempowering people and eventually losing them. Although the researcher has moved into other industries since, it appears that the same leadership dynamics are presenting themselves in the 21st century. Some leaders are encouraging others to develop driverless cars, more eco-friendly cars using different sources of energy, and they even use the word ‘innovation’ for internal and external branding. Other leaders are less visible, except when their operations cease to exist.

As an HR manager of a South African automotive manufacturing and assembly plant, I was exposed to different makes of vehicles coming from different countries in Europe, the United States of America (USA) and Japan. I was fascinated by the differences in designs and innovation practices between players and how our leaders got everyone to work together by pooling their expertise in the highly-competitive environment to bring about significant manufacturing plant upgrade. Being sent abroad to recruit experts in design and manufacturing engineering, production management, quality management and computer applications exposed me to even more diversity and how leader behaviours used diversity to enable or disenable technology innovation.

Another observation was the popularity of the iconic Lee Iacocca, an engineer who joined Ford and persuaded the CEO to approve the introduction of the Ford Mustang after the Ford Motor company had discontinued the production of the disastrous Edsel product. From Iacocca's biography, he could be described as a technology innovation leader who envisaged Mustang long before it had been designed. He engaged multiple stakeholders in the design and development of the car, he persuaded decision-makers to support the product, became a marketing pioneer and used media and political networks to make the Ford Mustang a successful technology innovation (Iacocca, 1984).

Unresolved question: "Which leader behaviours of Iacocca made the Ford Mustang success possible and which leader behaviours enable diverse entities to join hands in collaborative technology innovation?"

2.4.3. ICT sector as business systems analyst, marketing manager, and change agent

In the 1980s mainframe computers become increasingly useful as technology to automate work functions and information flow. Some highly-talented and ambitious people were drawn to this industry where they pioneered the establishment of new job titles such as programmers, systems analysts, and business analysts. While some leaders were keeping themselves busy with policies and procedures, procurement barriers and protocols to gain more control, others were encouraging their people to experiment with personal computers, share their learning, bringing in more diversity into decision-making processes to proactively accommodate various stakeholder requirements and celebrated technological breakthroughs.

My business process experience from the automotive industry became sought after in the ICT environment. I joined a software development organisation as business analyst responsible for engaging with the senior leadership and functional practitioners of our clients to assist them in crafting their strategic systems architectures in support of their business strategy and plan their systems portfolios to ensure that they would benefit from new technology. I noticed in this technology innovation facilitation role that some teams were significantly more productive and successful in delivering successful technology innovations than other teams. They often had similar teams with similar software and hardware skills, with similar client requirements in terms of systems complexity.

Unresolved question: "Which leader behaviours were having which effect on the performance of their teams in their pursuit of successful technology innovation?"

2.4.4. MBA studies and research into strategy formulation practices

Registering for my MBA soon exposed me to the academic thinking behind business processes and practices. Most classes took place after working hours and students insisted that the lectures and assignments should focus on essential learning and maintain high levels of productive throughput. What was difficult for many of us to grasp, was the different lecturers representing their particular domains as if those were the only issues that determined enterprise success. But we soon learnt that you should do what the presenter wants you to do rather than to challenge the status quo or beliefs. Such domain-specific claims became quite challenging when my MBA research project revealed its findings. My research focusing on strategy formulation practices in South Africa revealed that creative thinking during strategy formulation had paved the way for exploration of new possibilities, while less creative strategy formulation practices had resulted in organisations continuing to do what they had been doing before and were getting what they had been getting before. An academic reviewer advised me to focus my thesis content on scientific evidence rather than speculative observations. Some of the insights that I had to take out of my thesis were similar to what innovation thought leaders have been publishing in recent years. While I was attempting to express my awareness of cross-cutting creativity, the reviewer preferred content that would reinforce domain-specific proven knowledge.

Unresolved question: "Which leader behaviours create innovative enterprises that perform better than their competitors in the same markets and with similar resources?"

2.4.5. Building & construction – young researchers' symposium in Canada on the future of research

As a newly-graduated MBA the world of scientists and technologists beyond the ICT sector became appealing to me and I joined an organisation that has been in existence since 1945. They were still pursuing their mandate in South Africa which was to conduct multi-disciplinary research and technology innovation to support both industrial and public sectors in the national interest. As marketing and business development manager I was responsible for facilitating research and innovation directed growth during the early years of the new South Africa in the early 1990s.

The building and construction industry has been in existence for much longer than the automotive and ICT industries and perhaps had been less affected by technological innovation when South Africa was isolated from the rest of the world. This paradigm was challenged when the country had to take ownership of backlogs in housing and infrastructure and took a bold stance in declaring innovative new possibilities. Some leaders held on to conventional ways of planning, developing and delivering building components that met the requirements of the building regulations and practice codes. Other leaders experimented with improved information and decision-making tools for practitioners across the building and construction industry. What stands out for the researcher was the noticeable tension between these leaders in meetings, planning sessions, and executive feedback, as well as customer engagement settings. Some leaders used visionary language, declaring new possibilities and were working towards desired new futures, while others were conservative and showed much higher levels of resistance and scepticism. These two approaches also manifested in remuneration practices. Some leaders rewarded pioneering thinking, experimentation and sharing, while other leaders rewarded compliance, control and political manoeuvring to preserve what they had.

I had to represent our unit at an international construction industry futures symposium workshop attended by young researchers from over 20 countries. During our presentations about our institutional research portfolio priorities, it became clear that researchers from the developed economies only focused on SET research, while researchers from developing countries also considered socio-economic issues in their research. Most delegates could not understand why South Africa and India were experiencing problems in providing infrastructure and why we had socio-economic developmental research in our SET research portfolios.

Unresolved question: "Which leader behaviours enable innovators to innovate for a particular context and adapt a narrow or broader technology innovation focus?"

2.4.6. Top technology innovation leader interviews

BANWA was a project aimed at identifying future growth paths for the organisation at the time when the organisation had already secured most of the available research and development funding available in South Africa. As a member of the BANWA task team appointed by executive, I took part in the obvious product/market matrix optimisations but remained concerned about the lack of engagement from our staff in the project. I then identified the top 25 technology innovation leader performers in the organisation and conducted semi-structured interviews with them individually to gain a better understanding of what they were doing to have produced over 20 percent growth in income per year over at least five years and sustain staff satisfaction and client satisfaction levels exceeding 80 percent.

Three findings were significant enough to bring these to the attention of our executive. Firstly, none of the 25 top performers claimed any credit for their performance whatsoever, insisting rather, that it was the people and they were just making it possible for these people to perform. Secondly, no pattern could be found between fields of study and technology innovation performance but they all had at least a Bachelor's degree, but the majority had Master's or PhD degrees. Thirdly, all interviewees mentioned their exposure to diversity during their early childhood days. Examples of diversity were parents with different languages and families relocating to other countries or towns with the children attending new schools. This exposure enabled them to conceive possible new configurations, which other people were not always able to comprehend.

When asked about the big motivating forces in their lives, one of the interviewees replied "...I wake up every morning with a science fiction vision which gives me the energy to excite others and address any challenge".

Question: "Would it be possible to create an environment in which other leaders would emulate our successful leaders' behaviours?"

Another unforgettable experience was that of hosting a visit to South Africa by Rosabeth Moss Kanter who introduced me to her concept of "kaleidoscope thinking" as prerequisite for innovation; something that her audiences of leaders across South Africa still remembered years later. She described a kaleidoscope as a device made up of a set of fragments but the fragments are flexible and when the device is twisted one sees a different pattern. The fragments remain the same but we see new patterns by changing our view of them. Innovation leaders, she claimed, lead people out of their orthodoxy to think differently about reality and see new patterns and possibilities.

Unresolved question: "How can "kaleidoscope thinking" be made popular as leadership mechanism during innovation?"

2.4.7. International technology innovation facilitation and benchmarking

International innovation benchmarking and facilitation exposed me to good practices in other countries which extended my repertoire of technology innovation practices significantly. For purposes of this thesis the following examples were selected:

Finland: Their national system of innovation was reconfigured based on involvement of all stakeholders and culminated in national level innovation capabilities that made the country world leaders in several technology fields. When asked how they managed to involve all stakeholders, the answer from my host was "Finland is not a country, Finland is a club".

Unresolved question: "Which behaviours of leaders bring about a club-type atmosphere and global technology leadership?"

India: It was noticeable that India had sent more delegates than other countries to participate in knowledge diffusion workshops and that they shared information freely when given the opportunity. When asked about the reason for this, my host's response was "knowledge sharing is like one candle igniting another candle without diminishing its own strength".

Unresolved question: "Which leader behaviours enable innovation team members to exchange knowledge rather than hoarding their knowledge?"

France: A workshop on innovation lessons learnt attended by SET delegates from France and from South Africa revealed that the leadership challenges were very similar in both countries and that sharing of learning was perceived as most valuable to make delegates realise that others may have experienced and resolved issues similar to what they were experiencing.

Unresolved question: "Which leader behaviours make team members open to learning from other sources instead of re-inventing the wheel?"

Germany: Workshops held to explore and plan bilateral innovation opportunities revealed that German delegations would in most cases include specialists from multiple domains and that they would insist on important issues being identified and addressed with the aim of understanding and decision-making for long-term commitments.

Unresolved question: "Which leader behaviours enable systemic thinking in innovation?"

Malaysia: A taxi driver asked me: "We are nation building, how do you think we are doing?" and Malaysia's minister of science, technology and innovation spent a day with international delegates in workshop mode to learn more about their community level innovation systems. These are two of many experiences that I will remember as examples of what can be accomplished when people from diverse backgrounds work together towards a win-win future state.

Unresolved question: "Why are some leaders open to new learning and others not?"

Washington: My visit to the air and space museum where so many artefacts of flying machines are on display will remain one of my biggest defining moments. As I left the museum there was a display in the foyer that celebrated Albert Einstein as scientist. One of the banners displayed in big letters a message that resonated well with workshop delegates the next day: "Imagination is more important than knowledge".

Unresolved question: "What has to happen for a leader to acknowledge that imagination is more important than knowledge?"

2.4.8. Strategic human capital development assignment

Having been part of a delegation that presented a course on research and innovation management for parliamentarians, I became acutely aware of South Africa's relatively low investment in research and innovation and the country's relatively low numbers of scientists, engineers and technologists. We put together a team to develop a comprehensive human capital development strategy that fundamentally changed the demographics and depth of our science base. However, this was not easy because there was so much competition for the small number of maths and science pupils leaving school.

Unresolved question: "Which leader behaviours make their fields attractive to promising young talent, and enabled their teams to express desired futures based on stakeholder support and collaboration?"

2.4.9. University teaching

To date, this has been an interesting and new blend of experiences for me. Vibrant, energetic, naive youth with different appetite levels for learning, faculty activities organised as silos, like in other organisations that I have worked with, and some faculty members that harness skills and knowledge across boundaries to innovate and pioneer the generation and application of new knowledge.

Unresolved question: "Which leader behaviours of faculty enable collaborative knowledge generation technology innovation?"

2.4.10. Doctoral research

My doctoral research journey gave me daily exposure to knowledge creators and technology innovation leaders, academics, knowledge repositories and institutions that helped me to understand more about technology innovation leaders, the processes they use and the competencies that differentiate them from others.

Unresolved question: "Which leader behaviours enable subject domain experts to create value from new knowledge and become successful in technology innovation?"

Having presented a selection of defining moments that influenced the researcher's interest in the research topic it is fair to say that the questions raised remain largely unanswered. Other than speculative opinion sharing, practicing technology innovation leaders do not have a readily-available body of knowledge for benchmarking or to inform their technology innovation leadership decisions and practices.

2.5. SOME INNOVATION LEADERSHIP VIEWS FROM PERSONAL OBSERVATIONS

From hindsight and personal experience, some salient observations of common themes have emerged:

- Without exception successful technology innovation leaders excelled in applying imagination, building trust and radiating positive energy.
- Positional power of those making the rules often dominates in priority setting, resources allocation and performance reviews in innovation management systems that the researcher have been exposed to, which leaves innovators in such environments vulnerable and alienated, resulting in compromise.
- Leaders of innovation who were able to influence innovation systems through their credibility, and used qualifications or titles as last resort, have mostly performed better as team leaders in achieving innovation.

Some personal obervations on emerging themes:

- Ongoing increases in what is expected of innovation leaders, that do not correspond with increasing capabilities and capacity, create tensions that can destroy fragile relationships that are needed for people to join risky ventures or share ideas.

Personal views about technology innovation leader competencies for success:

- They are driven by near-science fiction visions, which they are able to visualise and share selectively with others who may contribute.
- They radiate positive innovation energy at all times, which makes others excited about trying new things and learning from mistakes.
- They understand the problems that they try to solve through innovation expectionally well and from different disciplinary and stakeholder perspectives.
- They are game changers with superb abilities to identify, attract, and leverage diversity in people to conceive and realise new possibilities.
- They behave in ways that earn trust and respect of others (peers, seniors, juniors and stakeholders).
- They realise their own limitations and surround themselves with complementary players.
- They elevate paradigms of others to new levels.
- They are masters at making new connections and integrating success ingredients.

2.6. RESEARCH CHALLENGES LINKED TO RESEARCHER EXPERIENCE

A life story is always a construction in which the researcher is implicated, which is why life story methodology should be considered by the qualitative researcher based on its strengths, such as its "...unambiguous emphasis on the point of view of the life in question and a clear commitment to the processual aspects of social life, showing how events unfold and interrelate in people's lives" (Bryman & Bell, 2011:471). Researcher bias may emerge, however, as a challenge in research situations where the researcher has to rely on personal experience to make sense of observed phenomena. Babbie and Mouton (2008:237) claimed that "...there are no ultimately true meanings for any of the concepts we typically study in social science ... prejudice has no ultimate correct definition, and whether a given person is prejudiced depends on our definition of that term."

Bias might be conscious or sub-conscious and in research the researcher needs to reflect on possible bias and compensate through appropriate mechanisms, which in this study include the following (Mouton, 2003):

- Research design – by adopting a mixed-method research design that has qualitative and quantitative phases with different validation procedures;
- Selection bias – by not selecting any particular organisation, theory, participant or geographic location as sole research input provider platform;

- Use of statistical techniques for analysis – by involving an expert colleague;
- Drawing inferences that are not supported by data – by reviewing mechanisms in the form of study leaders and colloquium presentations.

Another possible challenge related to the researcher's experience is that experience sharing may be viewed as anecdotal evidence which "...has become a central point of contention" and concerns "...the management of the boundary between experts and non-experts..." (Moore & Stilgoe, 2009:654).

Both the fields of management research and medical research have explored the use of anecdotal information in research, from which insights emerged, such as the following:

- Anecdotes are acknowledged as powerful tools that humans use to make decisions, but they are sometimes misused, undervalued, ignored or under-estimated.

  ...the important role of anecdotes must be acknowledged, studied and utilised ... to succeed in maintaining high quality and affordable health care services that can result from the conscientious and judicious use of the best available evidence, we must be creative and humble enough to accept that all types of information can play important roles. Anecdotes play a complementary role to formal research, and can facilitate the application of research evidence in health care decisions. (Enkin & Jadad, 1998:963)

- Anecdotal evidence may contribute to evidence-based research, especially in widely-debated issues such as public health (Nagaraj, 2006).
- Anecdotal evidence comes to be accepted in different ways by the main actors as an epistemic category, that it is multi-dimensional, open to interpretation as subjective reports, as an indicator of expert ignorance, and "...as a source of novel hypotheses ... we conclude that the flexibility of anecdotal evidence at the boundary between science and its publics can offer opportunities for participation and engagement, as well as exclusion and alienation" (Moore & Stilgoe, 2009:654).

This study incorporates personal experience of the researcher together with other acknowledged scientific research practices to build on the positive aspects reported above, while also contextualising such experiences as sources of "a novel hypothesis" (Moore & Stilgoe, 2009:654) and contributions to "…the dynamic spiral of meaning-making when developing a conceptual model" (Schurink, 2012:1).

2.7. RESEARCH QUESTION AS FOCUS

What are the technology innovation leader competencies deemed to be required for successful technology innovation? The researcher initially raised this question in light of a changing science and technology innovation landscape. Answers to this research question and related questions of relevance to South Africa have not been found in literature. While the researcher has worked with successful technology innovation leaders before and may have "novel hypothesis" views (Moore & Stilgoe, 2009:654) based on personal experience, scholarly answers derived from the rigour of scientific research are still needed to answer the question.

At the commencement of this study in 2012, the researcher had captured a PhD charter for this research journey:

> *The time has come to use the tools of management science to observe and report on leader competencies deemed to be required for successful technology innovation. Having had the privilege of meeting and interacting with global thought leaders in the technology innovation domain, the researcher hopes to connect some of the perspectives that had not been connected and captured in the growing body of knowledge before. In so doing, the researcher would like to see others expanding the body of knowledge so that innovation may benefit from maturing and capturing learning, as envisaged by Christensen, and claim its rightful place in management science, making leaders aware of better ways to bring about technology innovation and contributing to a more sustainable future through technology innovations in dealing with the greatest challenges of the 21st century.*

The main research question thus served as the researcher's primary guiding consideration for this study and is expanded into research sub-questions in Chapter 3 and Chapter 4 for clear alignment of the research activity with the conceptual model for this study.

2.8. CHAPTER CONCLUSION AND SYNTHESIS

This chapter disclosed the virtues of prior researcher experiences, while also acknowledging potential bias reflecting in research error in linking personal researcher experiences from various innovation-related management and functional specialist positions with the scientific rigour of the rest of this thesis.

From a curiosity perspective, the researcher's experiences had raised questions about the competencies of technology innovation leaders that have influenced the researcher's understanding and interest. These questions have culminated in the main research question which is central to the study, namely: What technology innovation leader competencies are deemed to be required for successful technology innovation.

From a scientific research perspective, this chapter served firstly to reveal the potential researcher bias that might present challenges related to familiarity with the domain and thus requiring deliberate measures of bias avoidance, and secondly to reveal potential bias in one section of the thesis, rather than to present multiple repititions (Babbie & Mouton, 2008:218; Bryman & Bell, 2011:98).

The inclusion of a thesis chapter on the experience of the researcher may be seen as unconventional by reviewers, yet the inclusion of researcher experience is accommodated in ethnographic research to convince readers of the reality of the events and situations described, and the plausibility of the researcher's interpretations of research data (Bryman & Bell, 2011: 703). The emphasis of this study, however, remains the main research question posed in Chapter 1and concluded in Chapter 7 and while individual views are important only in so far as they represent general tendencies (Bryman & Bell, 2011: 705).

CHAPTER 3

THEORETICAL FOUNDATIONS OF THE STUDY

3.1. CHAPTER INTRODUCTION

This study aims to identify technology innovation leader competencies deemed to be required for successful technology innovation. As discussed in Chapter 1, a preliminary literature review revealed that the concept of technology innovation leader competencies deemed to be required for successful technology innovation had not been covered in current scholarly literature. In scientific research, literature reviews aim to identify and synthesise prior empirical research to establish what is known about the phenomenon being studied before embarking on futher research (Bryman & Bell, 2011:103). In this study the literature review is guided by the provisional conceptual model presented in Chapter 1 to guide the selection of topics, identify the literature to review and analyse, after which the conceptual model is updated and inputs synthesised to reveal further research requirements to answer the research questions. Introductory considerations pertaining to the current knowledge base are presented. Clarity is then provided on regularly-used terms for consistent interpretation throughout this study before the rest of the research themes presented as elements in Figure 3.1 are discussed.

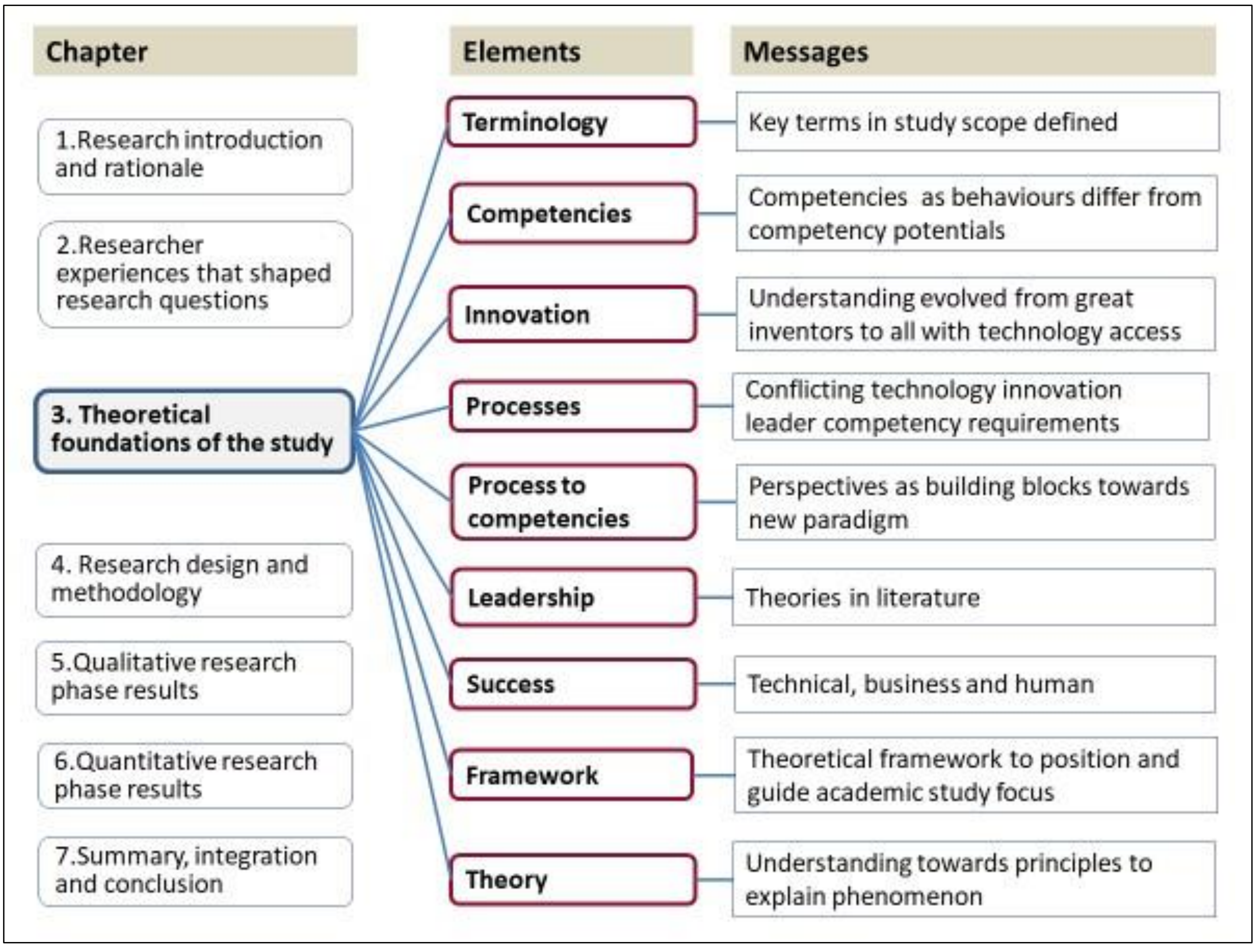


Figure 3.1: Thesis map of Chapter 3

To provide a theoretical grounding for this study, the concept of theory is briefly discussed. A 'theory' is an explanation of observed regularities to explain a phenomenon, while a "theoretical perspective" is a high level of abstraction in relation to research findings (Bryman & Bell, 2011:8). The level of abstractness may be so great that the researcher would find it difficult to make the necessary links with the real world at a level of sufficiency that might guide or influence the collection of empirical evidence (Bryman & Bell, 2011:8). Considering this claim, it is important for this study to bridge the gulf between theory and the real world by seeking to "...understand and explain a limited aspect of social life" (Bryman & Bell, 2011:10). Bryman and Bell (2011:11) further described theory as "...something that guides and influences the collection and analysis of data", which suggests that "research is done in order to answer questions posed by theoretical considerations". Alternatively, theory can be seen as "something that occurs after the collection and analysis of some or all of the data associated with a project". In the first instance, the research process is deductive and the research process is about finding theory that can be used for observations and findings. With induction, the process is reversed and starts with observations, findings and results that may contain deductive elements and where an iterative research strategy is adopted by "...weaving back and forth between data and theory" (Bryman & Bell, 2011:13). In established disciplines the research can start with the selection of an appropriate base theory, casted in a causal framework. The lack of such theories, however, would require the researcher to considering other available knowledge for inclusion in a nested model framework, if possible establishing an integrated theoretical framework for testing (Malhotra, 2015), as is done in this study.

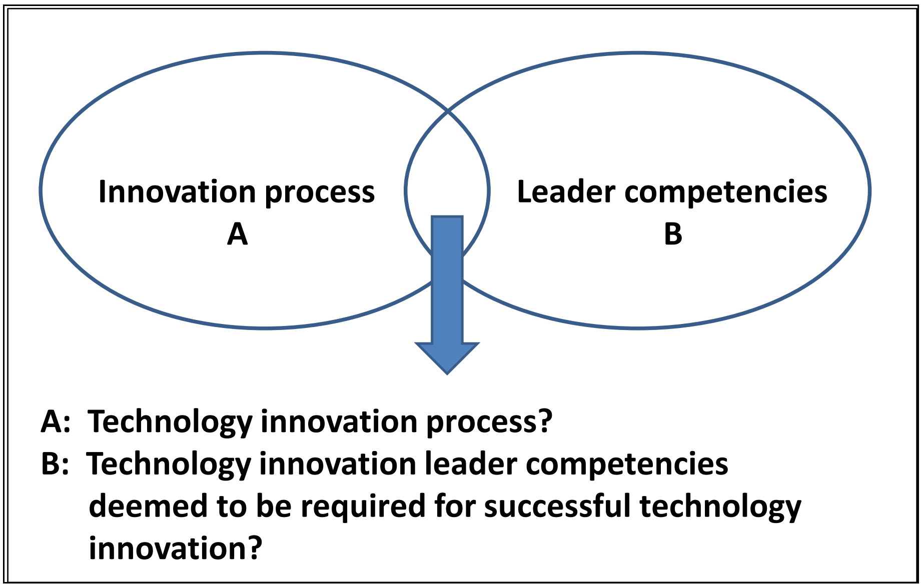


Figure 3.2: Question derived from the conceptual model to guide a literature review

As indicated in the provisional conceptual model in Figure 1.6, two primary innovation areas of interest to this study include: (i) the theory related to innovation processes; and (ii) technology innovation leader competencies that were deemed to be required in the pursuit of successful technology innovation, as conceptually presented in Figure 3.2. Based on the literature review, a more comprehensive conceptual model is presented in Figure 3.32 to derive a theoretical framework presented in Figure 3.33.

The innovation knowledge base has been growing exponentially, as indicated in Figure 1.3, suggesting an increased availability of scholarly material to consider as foundational inputs for further research (Mouton, 2003). Not all innovation literature, however, seem appropriate for this study which necessitated the adoption of a theoretical framework to inform the selection and review of available material based on the following considerations that can be summarised as a search for the "most recent, credible and relevant scholarship" in the area of interest (Mouton, 2003:87)

- This study reviewed the work of other scholars who have investigated the same research problem, to learn from how they have theorised and conceptualised on issues, what they have found empirically, what instrumentation they have used and to what effect. For Bryman and Bell (2011: 92), literature reviews confirm the credibility of researchers as knowledgable in their chosen field, and should not merely be a reproduction of theories and opinions of other scholars, but also interpret what they have written and possibly use their ideas to support a particular argument.
- Criteria for a good literature review (Mouton, 2003:88) include that it should be "exhaustive in its coverage of the main aspects of the study", fair in its treatment of authors, topical and not dated, not be confined to Internet resources, and it should be well organised. Organising by theme or construct is used in this exploratory study and the key constructs could be both quantitative and qualitative as implied by the formulation of the research problem (Mouton, 2003:91,93).

The preceding discussion provide structural guidance, yet seems to leave important scoping decisions to the subjective interpretation and judgement of the researcher who should not simply be driven by the research questions because "the more you read the more clarity you get, which often leads you to change the formulation of your research problem. It is truly an interactive and a cyclical process" (Mouton, 2003:91).

No single discipline appears to deal with all aspects of innovation. Therefore, a cross-disciplinary approach is required for an overview of the role of innovation in business (Arthur D. Little, 2015) and in society (Fagerberg, 2003). Innovation increasingly requires "...the creative combination of different disciplines and perspectives" (Tidd & Bessant, 2013:107).

The selection of literature was thus guided by the main research questions and sub-questions listed in Table 3.1, as well as the terminology regularly used in this study, as discussed in the next section.

Table 3.1: Main research question and research sub-questions

Main research question	Research sub-questions (SRQ)	Reference section
RQ1 What are the technology innovation leader competencies deemed to be required for successful technology innovation?	SRQ 1.1 Which innovation process can be considered as basis for the identification of leader competencies?	Section 3.5
	SRQ 1.2 Which alternative innovation process should be used for identification of leader competencies?	Section 3.6
	SRQ 1.3 Which leader competencies are required across the technology innovation process?	Section 3.7

3.2. CLARIFICATION OF REGULARLY-USED TERMS

None of the terms used in the title of this study are new, yet the vast range of sources providing differently-worded definitions appear to vary in terms of nuance, depth, as well as the audiences catered for. As justified in the research design chapter, this study adopts a strong practical bias, which explains why definitions of a more practical nature and used by practitioners have been selected. Online searches for definitions of the key concepts of this research yielded millions of possible permutations and interpretations. For the sake of academic integrity and consistency, the following definitions apply and are further discussed in the respective sections that follow.

3.2.1. Competencies

Competencies are “sets of behaviours that are instrumental in the delivery of desired results” (Bartram, 2006:2). Related theory is discussed in Section 3.3.

3.2.2. Competency profile

A competency profile describes the required competencies in sufficient detail for gaps to be assessed and addressed through human capital development programmes (Kaplan & Norton, 2004:225). A competence profile eminating from this study is proposed in Chapter 7.

3.2.3. Technology

Technology is defined as the application of scientific knowledge for practical purposes in the form of machinery or equipment developed from this knowledge (Oxford Dictionary, 2009:954).

3.2.4. Invention

An invention is the first manifestation of an idea, which is one of the steps in an innovation process of bringing an idea “to widespread and effective use” through commercialisation, implementation or adoption of the invention (Fagerberg, 2003; Tidd & Bessant, 2013:18).

3.2.5. Innovation

Innovation is the process of turning ideas into reality and capturing value from them – and only if we can manage the whole process, is innovation likely to be successful (Tidd & Bessant, 2013:21). Innovation theory is reviewed in Section 3.4 and innovation processes in Section 3.5.

3.2.6. Technology innovation leader

A person who has led a team to successful technology innovation (Stanford Graduate School of Business, 2015) and can be reffered to as a leader of technology innovation.

Innovation leaders may be categorised as a strategic job family, which means that they are in positions in which people with the right competencies have the biggest impact on enhancing critical internal processes such as innovation (Kaplan & Norton, 2004:225).

3.2.7. Knowledge-intensive organisation

A knowledge-intensive organisation is one where work is of an intellectual nature that requires well-educated qualified employees as the major part of the work force (Mohanta, 2015).

3.2.8. Technology innovation leader competencies

Technology innovation leader competencies are sets of leadership behaviours, which are considered instrumental in facilitating and delivering technology innovation outcomes throughout the innovation process (Swart, 2013:70). Section 3.6 reflects on innovation process perspectives for the identification of competencies.

3.2.9. Leadership

Leadership is about inspiring others to higher levels of performance. In innovation leadership, higher levels of performance may include economic improvement, and what people believe they can and cannot do, including being creative, engaging in innovation and embracing change. Great leaders are able to bring out the best in others in all senses – their ability, their selfworth, and what the individual can achieve in life (Von Stamm, 2013).

3.2.10. Success

Technology innovation success is the achievement (Oxford Dictionary, 2009) of capturing value from turning ideas into reality (Tidd & Bessant, 2013:21). Success perspectives are discussed in Section 3.8.

3.3. COMPETENCE AND COMPETENCY THEORY

This study aims to identify technology innovation leader competencies deemed to be required for successful technology innovation and early clarity on competency-related terms serve as reference base for the study. This section extends the literature review into the theoretical origins, evolutionary thinking and recent shifts in approaches towards competency profiling and assessment, including post-modernistic challenges posed to the notion of profiling.

3.3.1. Competence and competency defined

The literature reviewed in the field of competency theory emphasises different aspects of the term portraying an inconsistent meaning of the term and its synonyms, such as competency, ability, capability, proficiency, accomplishment, expertise, skill and prowess (Oxford Dictionary, 2009). This section examines some of the pertinent competency-related issues identified in the literature before shifting the emphasis towards technology innovation leadership competencies deemed to be required for successful technological innovation. Since technology innovation leader competencies are at the core of this study, it is important to subscribe to a particular interpretation of competency to be used throughout this thesis. Where this study refers to competencies or competency, it shall imply individual behaviours required to be competent.

'Competence' is the ability to do something well (Oxford Dictionary, 2009). Competence at organisational level may include the differentiating strengths of a business and the concept of core competency which is a combination of multiple resources and skills that distinguish a firm in the market place in a way that provides access to multiple markets and cannot be easily copied (Prahalad & Hamel, 2013). Creative ability in business could be a core competency of an organisation, but in modern organisational forms the implications are considerable in terms of leadership requirements (Hamel, 2002).

A competence at a leader level is referred to as a competency which is a set of defined behaviours that provide a structured guide enabling the identification, evaluation and development of the behaviours in individual employees (Bartram, 2006). Competencies provide organisations with a way to define in behavioural terms what it is that people need to do to produce the results that the organisation desires. A competency of being able to work with different cultures may, for example, not be sufficiently described in behavioural terms, yet conveys behavioural clarity when described as working effectively with people who define problems differently (Downey, Lucerna, Moskal *et al.,* 2006).

The individual competencies of leaders responsible for achieving technology innovation are investigated in this study. Therefore, the selected literature sources, fragmented and non-coherent as they are, need to be reviewed because they may have unintended implications for the study if left open ended:

- Competency is a condition of being capable or able or a state of being legally competent or qualified (Dictionary.com, 2014).
- Competency fitness is the quality of being qualified (Free Online Dictionary, 2014).
- Competency is the ability to repeatedly perform a task to a given standard (MTCS, 2014).
- Competency is the capacity of a person to understand a situation and to act reasonably (BusinessDictionary.com, 2013b).
- Competency is the ability to do something well, the state of being adequate, having the necessary skill or knowledge to do something successfully (Oxford Dictionary,2009).

3.3.2. Levels of being competent to lead innovation

Over three decades ago, Drucker (1982:503) wrote:

> *An established company that, in the age demanding innovation, is not capable of innovation is doomed to decline and extinction. And a management that in such a period does not know how to manage innovation is incompetent and unequal to its task. Managing innovation will increasingly become a challenge to management and a test of its competence.*

The distinction made by Drucker (1982) builds on the claim in the previous section that the competence to lead innovation can be observed at different levels.

At organisational level the core competency literature emphasises how product excellence along a given functionality dimension can be leveraged to access other applications and market segments (Kaplan & Norton, 2004:150) and may include infrastructure, equipment, know-how and skills (CSIR, 2010). Innovation competence may also be studied in groups or teams (Gliddon & Rothwell, 2016).

This study explores being competent to lead innovation at the ‘leader of innovation’ level (Von Stamm, 2013) which is typically at a project level. In this study the concept thus refers to the competencies of individual innovation leaders and specifically technology innovation leader competencies that are deemed to be required for successful technology innovation.

3.3.3. Leader competencies exclude competency potentials

Competencies are “sets of behaviours that are instrumental in the delivery of desired results” and excludes “...personal attainments and attributes that have no behavioural expression within the work environment.” from this study (Bartram, 2006:2). Competencies further exclude what SHL calls “competency potential” (Bartram, 2006:2).

Researchers have identified "characteristics that might have something to do with being effective...", like being intelligent, seeking responsibility and being good communicators but "measures of these traits yield inconsistent relationships with being a good leader" (Tidd & Bessant, 2013: 112-113). They point out that no brief and universal list of enduring traits apply to all leaders in all conditions. The same applies to the use of personality types and preferences in determining behaviours of leaders to positively influence technology innovation performance (Hammett, 2007). In a similar vein, Gliddon (2006:81) rejected previous findings of Fenwick and Sheasley by claiming that their research "...assessed the inherent characteristics of innovation leaders rather than these leaders' competencies in leading innovation in an organization". Figure 3.3 illustrates differences between competencies and competency potentials including dispositions and attainments on the other.

In this study competencies relate to the "...behaviours underpinning successful performance; what it is people do in order to meet their objectives; how they go about achieving the required outcomes; what enables their competent performance" (Bartram, 2006:3).

This study aims to identify the technology innovation leader competencies deemed to be required for successful technology innovation and adopts the SHL definition of 'competencies', which are defined as sets of desirable behaviours. The SHL term of 'competency potential' encompasses the individual attributes necessary for someone to produce the desired behaviours and falls outside of this study (Bartram, 2006:3).

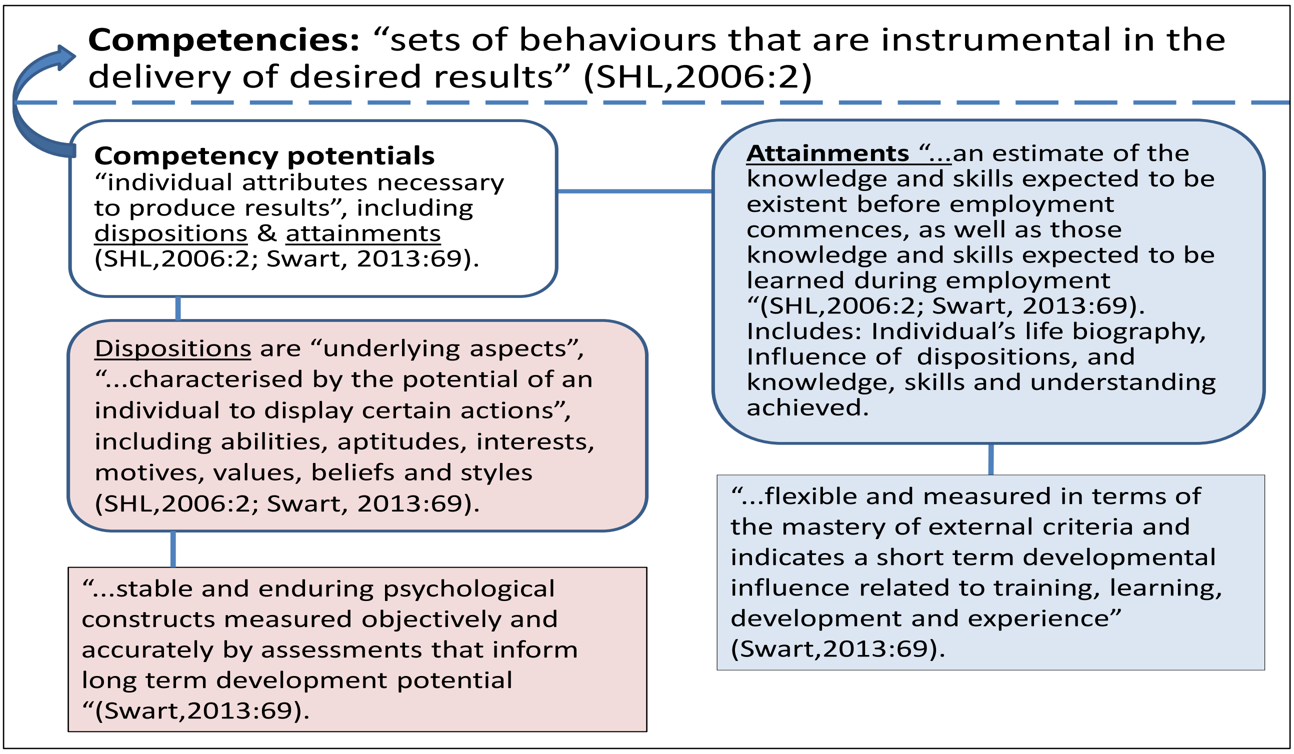


Figure 3.3: Scoping definitions: competencies

Dispositions are stable and enduring psychological constructs measured objectively and accurately by assessments that inform long-term development potential, while attainments are flexible and measured in terms of the mastery of external criteria and indicates a short-term developmental influence related to training, learning, development and experience (Swart, 2013:69).

3.3.4. Changing emphasis in leader competency frameworks

Based on their extensive review of leadership theory and competency frameworks covering approximately seventy years, Bolden, Gosling, Marturano and Dennison (2003), observed that shifts in theory correspond with shifts in leader competencies over time. Before Belbin's team role theory, leader competency was seen as the solo leader or 'shaper' heading up a team of followers as opposed to a team leader competent to harness complementary strengths of people towards a mission and vision which they can act on as they see fit (Bolden *et al.,* 2003: 14). Table 3.2 was compiled from their review to itemise evolving schools of thought from which Figure 3.4 was derived to illustrate the move away from a task orientation to a cause orientation and from an individual leader to shared leadership where the leader causes collective team effort. It can be argued from these observations that competencies of the leader differ from what was required in an industrial age leader paradigm to what is required in a knowledge age (Uhl-Bien, Marion & McKelvey, 2007).

Table 3.2: Leadership theories reviewed by Bolden *et al.* (2003)

Schools of thought	**Leader description**
Great Man theories	Leaders are exceptional people, born with innate qualities, destined to lead. Role-models were primarily male, military and Western.
Trait theories	Lists of traits and qualities drawn from virtually all adjectives in the dictionary to describe some positive or virtuous human attribute.
Behaviourist theories	Concentrate on what leaders do rather than qualities. Patterns of behaviours were observed and categorised as leadership styles. Examples: • McGregor's Theory X & Theory Y Managers (1960) • Blake and Mouton's Managerial Grid (1964)
Situational leadership	Leaders respond to specific situations that require different styles and leadership styles may differ at different levels in the same organisation. Example: • The Hersey-Blanchard Model of Leadership.
Contingency theory	Refinement of situational leadership to focus on situational variables that best predict the most appropriate of effective style for particular circumstances. Examples: • Fiedler's Contingency Model • Tannenbaum & Schmidt's Leadership Continuum • Adair's Action-Centred Leadership Model (1973) (Adair, 2009)

Table 3.2: Leadership theories reviewed by Bolden *et al.* (2003) (continued)

Schools of thought	Leader description
Servant Leadership	Emphasises the leaders' duty to serve his/her followers – leadership thus arises out of a desire to serve rather than a desire to lead. Servant-leaders encourage collaboration, trust, foresight, listening, and the ethical use of power and empowerment. Emphasis is on serving a higher common purpose. Robert Greenleaf (1970)
Followership and team Leadership	Leaders asks questions rather than giving answers, provide growth opportunities for people, work with people regardless of hierarchical or functional position, help people find collaborators, seek common understanding instead of consensus. • Katzenbach and Smith (1994) • Belbin (1970-1993)
Transactional leadership	Emphasis is on leader-follower relationship with mutual benefits derived from a form of 'contract' through which leaders acknowledge in ways such as rewards or recognition, the follower commitment or loyalty. Focus is on doing the job and making a living, power, position, short term, tactical, role compliance, structures and systems that reinforce bottom line, maximise efficiency and profits. • Covey comparisons (1992)
Transformational leadership	A leadership approach that causes changes in individuals and social systems. Relates to envisioning and implementing the transformation of organisational performance based on meaning, purpose and values, morals and ethics, longer term, structures and systems to reinforce overarching values and goals and pursue new possibilities. • Bass & Avolio (1993) emphasised idealised behaviours, inspirational motivation, intellectual stimulation, individualised consideration and idealised attributes of respect trust and faith. • Hooper & Potter (1997) emphasised setting direction, setting an example, communication, alignment, bringing out the best in people, the leader as change agent and providing decisions in crisis and ambiguity.
Dispersed leadership	Emphasises social relations in the leadership contract, leader accepted by their followers and the realisation that no one individual is the ideal leader in all circumstances. Also referred to as 'informal', 'emergent' or 'dispersed' leadership, this approach argues a less formalised model of leadership where the leader's role is dissociated from the organisational hierarchy. Individuals at all levels in the organisation and in all roles (not simply those with an overt management dimension) can exert leadership influence over their colleagues and thus influence the overall leadership of the organisation. • Heifetz (1994) • Raelin (2003)

Figure 3.4 conveys a graphic interpretation of the changes in leadership theory observed by Bolden *et al.* (2003) to indicate a migration of leader focus towards cause and a shift from the single leader to dispersed leadership.

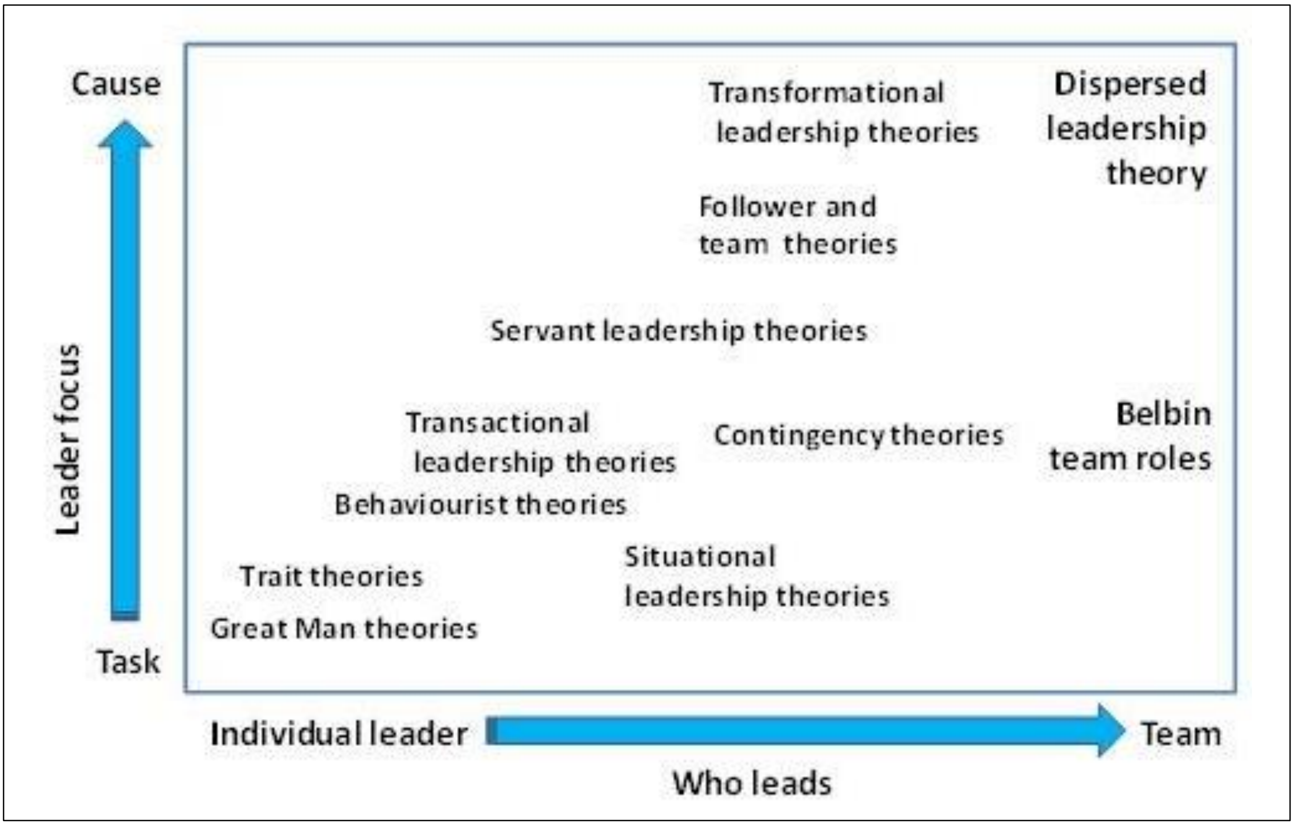


Figure 3.4: Leadership theory changes from 1930 to 2003

Source: Adapted from Bolden, Gosling, Marturano & Dennison, 2003:37.

The work of Bolden *et al.* (2003) is also significant for this study because of their observation that references to innovation were found in a collection of 24 leadership models and competency frameworks used in both the public and business sectors, of which only the following three specifically mentioned innovation leader competencies:

- The National College for School Leadership's Hay McBer Model of 1999 acknowledged that innovation may be required in learning delivery that should "...be developed through experiential and innovative methodologies" (Bolden *et al.,*2003: 23).
- The Senior Executive Service identified "Creativity and Innovation" as one of 26 leader competencies across five categories and specifically the "leading change" category (Bolden *et al.,* 2003: 24).
- The Northern Ireland Senior Civil Service Core Criteria Competency Framework acknowledged that leaders should be capable of "...managing resources innovatively" (Bolden *et al.,* 2003: 21).

3.3.5. Studying competencies to lead innovation

The competence and competency discussion so far differentiated between competency and competence by introducing levels of competence to lead innovation, the concept of competency potentials and the changing emphasis in competency framework over the past 70 years. From these observations, however, some authors have commented on the challenges involved in studying leader competencies.

The complexity of leader behaviour "constitutes a major stumbling block in specifying how creativity contributes to leader performance" (Mumford & Connelly, 1991: 292). Rosenzweig (2007: 7) pointed out that highly-successful leaders tend to be evaluated through a 'halo effect' rather than actual performance backed by independent data. Hamel (2011) identified slow and inadequate progress of innovation in management practices for success in the complex, challenging and dynamic management landscape and Gill (2011) claimed that some leader behaviours may be more causily related to effective or superior performance than others.

Elkins and Keller (2003) contributed a seminal paper on the behaviours of project leaders in science-based organisations that influenced their innovation performance. Gliddon (2006:10) investigated innovation leader competencies and defined competencies as internal capabilities that people bring to their jobs; capabilities which may be expressed in a broad, even infinite array of on-the-job behaviour.

While the importance of competencies is emphasised by those involved in leadership development, no agreed approach to the identification and formulation of competencies could be identified in literature (Illeris, 2009:15). Previously-published competency profiles tend to be presented in generalised formats that do not visibly accommodate innovation and fail to disclose the research protocols applied in their identification and formulation. Some insist that competencies include sets of skills, knowledge, behaviours and attitudes that a person needs to be effective in a position (Slocum, Jackson and Hellriegel, 2008:4). A competency is a cluster of related abilities, commitments, knowledge, and skills that enable a person to act effectively in a job or situation, according to The Business Dictionary (2013b). Some contributions are so broadly defined and generic that they cannot be described as new or different or even of relevance to the scholarly community. (AACSB, 2012).

In their overview of the evolution of Competency-based Assessments in HR practices, the Media Solutions Group (2013) reported that competencies in business have been defined since the conventional job description came into being but that the latest trend is to select and hire incumbents who would be competent to move beyond narrow job description to and to specialise or generalise in their work as and when required by changing conditions (Media Solutions Group, 2013). A study into the leader behaviours that contribute to superior performance (Zhang, Zhiqiang. & Yongyue, 2013), and innovation in the case of this study, should be reviewed whenever future trends and changes in strategy warrant new skills and behaviours (SHRM, 2008), suggesting that studies into leader competencies remain context-related.

> *New leadership competencies are required to navigate disruption. This means uncovering one's deeper motivations to drive meaningful opportunities for others; pushing personal boundaries to challenge one's own assumptions; taking steps into the unknown with the view that failure isn't failure at all but rather a stepping stone to learning and progress; and tuning into surprises as a kind of portal for gaining new insights and uncovering opportunities. To lead disruptive innovation successfully requires that we disrupt the most fundamental mindsets and behaviors that have led us to our current success.* (Kaplan, 2012:11)

In appreciation of the complexity of leader behaviour, the focus of this study is thus at the individual behavioural level of a competent technology innovation leader at an application level, as indicated in Figure 3.5. A similar focus to Figure 3.5 was adopted by Swart (2013:36) who commenced his research with respect to the development of an innovation leadership questionnaire (ILQ) by linking the knowledge, skills and attitudes of the innovation leader over the innovation process. Later in the ILQ research process, however, Swart stated that "...it soon became clear through discussions with colleagues that they favour an approach that deals with innovation leadership competencies rather than innovation leadership knowledge, skills and attitudes".

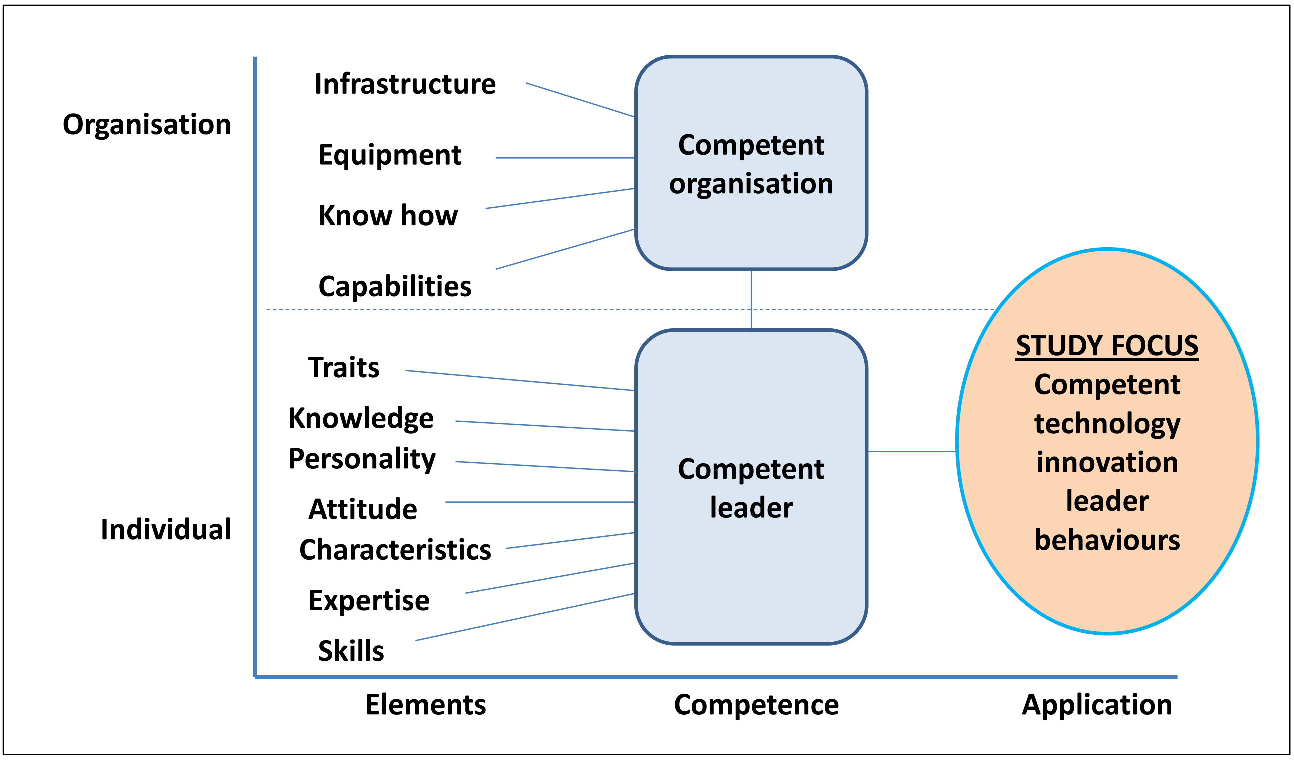


Figure 3.5: Competency theory and study focus

Other recent studies appear to have followed a similar approach by focusing on leader behaviours, rather than potential (Botelho, Powell, Kincaid & Wang, 2017: 72-77) who reported their analysis of 17 000 executive assessments, showing that charisma, confidence and “pedigree” have little bearing on high performance, including technology innovation.Instead, high success performance could be linked to leaders being decisive when they cannot wait for perfect information, to engaging stakeholders for impact by understanding their priorities and then alligining them around a goal of value creation, adapting proactively by keeping their eyes on the long term while treating mistakes as learning opportunities, and then deliver results in a reliable fashion by steadily following through on commitments.

3.4. REVIEW OF INNOVATION THEORY

As discussed in Chapter 1, the formalised management of innovation represents a relatively-new and complex area for management scholars (Lord, 2005:23; Shapiro, 2002:3; Ott, 2010:5). Some of the contributions to date are discussed to guide the selection of theories for this study (Malhotra, 2015).

3.4.1. Historical and contemporary innovation perspectives

Early innovation observations may not have been published as innovation studies, but recorded as history or clustered together with concepts such as “science studies” or “science policy studies” (Fagerberg, 2003:2). More recently, innovation studies have emerged as a research field in which science is acknowledged as one among several ingredients in successful innovation. The way in which innovation is organised has also undergone changes as historians of technology have pointed out the growing significance of technology in innovation and acknowledged that innovation is a systemic phenomenon that works across disciplines, over time and across sectors or industries (Fagerberg, 2003). At the time of publishing, Fagerberg (2003:13) also observed that “we know much less about why and how innovation occurs than what it leads to” and that most research work focused on cognition and knowledge of individuals, rather than organisations and that innovation has been studied by different communities of researchers with different backgrounds, who have failed to communicate effectively with one another and are thus impeding progress in the field

Innovation has since been labelled as both the most important and overused word in America (Brands, 2014). A Google search on 21 November 2013 ‘define innovation’ yielded 98.4 million hits. Increasingly policy makers and business leaders declare their desirable anticipated innovation outcomes and their commitment to foster innovation, the most recent trend being improved ideation and idea management practices (Arthur D. Little, 2015).

The South African focus of this study acknowledges the particular context to which innovation applies, based on the work of a Ministerial Committee in 2012, as described by Prof Cheryl de la Rey in her capacity as vice-chancellor of the University of Pretoria and chairperson of the National Advisory Council on Innovation: "...apply knowledge to advance economic and social purposes – that innovation, particularly when supported by government resources, needs to extend beyond any commercial and economic indicators..." (Wild, 2015: vii).

3.4.2. Relevant current innovation theories and concepts

The review of literature regarded to be relevant, i.e. "closely connected or appropriate to the current subject" (Oxford Dictionary, 2009:788) did not mention technology innovation leaders, which left the researcher without clear boundaries for interpretation of available material. A broad intuitive inclusion of material may yield high volumes of literature of no direct relevance to the study, while ignorance of their existence may result in no directly related material being reviewed.

The strategy adopted for the literature review was thus based on reviewing a relatively small sample of materials guided by the two central issues of innovation process and leader competencies as presented in Figure 3.2 in support of answering the main researdh question. As both the process and the competencies reviews were being observed from an innovation perspective, the literature review strategy commenced with a review of material on innovation theories and concepts.

Following their comprehensive literature review of creativity and innovation, Anderson, Potocnik and Zhou (2014:1318) declared a lack of theoretical advances across creativity and innovation literature in the past decade and that "... there remains a real need for more, and more radical theory-building contributions". Smith (2010:68) endorsed the need for new theory by describing innovation as a complex phenomenon that embraces several academic disciplines. While such theories may not exist yet, Bryman and Bell (2011:10) emphasised that in many instances theory is latent or implicit in the literature of existing available theories relating to a research topic that can be used to establish a nested model based on their coherence, necessity and sufficiency (Malhotra, 2015).

According to Bryman and Bell (2011:10), such derived perspectives act as the equivalent of a theory and enables the researcher to seek and resolve inconsistencies based on research questions that arise from an interrogation of the literature that allows for data collection and analysis that aim to resolve the research problem. This study should thus consider theoretical perspectives that relate to the process of turning ideas into reality and capturing value from them (Tidd & Bessant, 2013) as well as the strategic considerations of applying knowledge to advance economic and social purposes (Wild, 2015), as summarised in Table 3.2 and discussed thereafter.

Table 3.3: Summary of innovation theories with implications for this study

	Existing theories	Study implications for technology innovation leader
i	Absorptive capacity theory (Smith, 2010; Tidd & Bessant, 2013; Flatten, Adams & Brettel, 2014)	Organisational ability to recognise the value of new external information, assimilate new knowledge and technology and apply it to create value.
ii	Creativity model theory (Lubart, 2001)	Recognise and lead beyond limitations of current boundaries in creative thinking models such as Wallas' classic four stages.
iii	Customer value theories (Slater, 1997)	Integrate value creation in the technology innovation process by working intensively with envisaged customers to understand their latent needs and what they would perceive as value.
iv	Disruptive innovation theory (Christensen, 1997)	Understand technology innovations may create new markets and value networks that displace established firms, products and alliances.
v	Dynamic theory of strategy (Porter, 1991)	Integrate external and internal forces to influence and respond to changes in how value is created.
vi	Economic value theories (Schumpeter,1942; Solow, 1956)	Accept replacing current technology with new technology to support economic growth.
vii	Innovator's dilemma theory (Christensen, 1997)	Avoid failure to notice game changing transformations in their environments and being unable to respond, transform and redirect the firm in time to integrate the new rules of the game.
viii	Innovation systems theories (Anderson *et al.,* 2014; Brynjolfsson & Hitt, 2000; De Wet, 1991; Kotsemir & Meissner, 2013; Perez, 2009)	Make innovation the responsibility of those involved in a system of innovation to deliver what receivers regard as value and the leader must know what innovation value entails to lead the system.
ix	Stakeholder theory (Donaldson & Preston, 1995)	Assume significance of interests of stakeholders and collaborators in innovation.
x	Systems integration theories (Bruton & White, 2011)	Understand that technology innovation demands integrative capabilities of the technology innovation leader.
xi	Technology functionality grid (Lochner, 2011; Van Wyk, 2012)	Understand that different technology functionality perspectives make up a panoramic view for planning purposes.
xii	Technology innovation theories (Teece, 2010; Tidd & Bessant, 2013)	Reconfigure organisation for effectuation of innovation and technology change; Innovation process goes beyond invention to include adoption.
xiii	Technology innovation typologies (Smith, 2010)	Know that technology innovation may range from incremental to radical with other variations in between that all require integrative capabilities of a technology innovation leader.
xiv	Technology 'S-curve' theory (Smith, 2010)	Acknowledge that new technologies have different yield levels over time. Initially low engineering effort yields high returns and later additional effort does not yield more returns.
xv	Technology zone of influence theories (Gopalakrishnan & Damanpour, 1997)	Distinguish between technology and non-technical innovation is becoming difficult as technical and administrative innovations converge.
xvi	User involvement theory (Schweitzer, Gassmann & Rau, 2014)	Engage users and involves them in co-creation.

3.4.2.1. Absorptive capacity

Absorptive capacity is the ability of a firm to recognise the value of new, external information, assimilate it and apply it to commercials ends (Cohen & Levinthal, 1990). Smith (2015:64) added that this capacity is important for technology innovation because it enables the firm to detect early signals of emerging changes in the technology innovation landscape and the broader environment that may have implications on the technology innovation being pursued or to be pursued by the firm. It includes the ability to bring such observations into the organisation, synthesise it in conjunction with the internal knowledge of the firm and decide whether or not to apply the learning to the firm's benefit (Osei, 2014). Absorptive capacity has not yet been linked to leader competencies before and is further discussed in coming sections where technology innovation leader competencies are identified.

3.4.2.2. Creativity model theory

The revised stage-based creativity theory (Lubart, 2001) challenges the classic four stages creativity models of Wallas (1926) that suggested a linear sequential flow of creativity stages, namely: (i) preparation, (ii) incubation, (iii) illumination and, (iv) verification. Lubart agreed with Guilford (1950) that these stages are superficial and ignorant regarding sensitivity to problems, capacity to produce many ideas, ability to change one's mental set, ability to reorganise, ability to deal with complexity and ability to analyse the influence of external factors during innovation.

3.4.2.3. Customer value theories

Customer value-based theories provide a compelling argument for why customer value must be the focus of business (Slater, 1997:162). Customer value-based theory suggests that technology innovation leaders should minimise their risk and maximise learning by working intensively with customers to understand their latent needs by work collaboratively in cross-functional teams and undertaking low-cost marketing experiments to bring about successful technology innovation perceived by the customer as value (Slater, 1997:165).

The term 'value' is used widely in innovation literature, yet seldom defined. For purposes of this study the term is broadly interpreted to include one of or a combination of the following three definitions (BusinessDictionary.com, 2013d):

- *In Accounting*: The monetary worth of an asset, business entity, good sold, service rendered, or liability or obligation acquired.
- *In Economics*: The worth of all the benefits and rights arising from ownership. Two types of economic value are (i) the utility of a good or service, and (ii) the power of a good or service to command other goods, services, or money, in voluntary exchange.

- *In Marketing*: The extent to which a good or service is perceived by its customer to meet his or her needs or wants, measured by the customer's willingness to pay for it. It commonly depends more on the customer's perception of the worth of the product than on its intrinsic value.

3.4.2.4. Disruptive innovation theory

Creative destruction was coined by economist Joseph Schumpeter to accentuate the human ability to bring about technology innovation which has been recognised as a critical part of societal progress (Schumpeter, 1842). The disruptive innovation theory (Christensen, 1997) has been used to explain all kinds of disruptions and this is viewed as a mistake by Markides (2006:19) who believes more emphasis should be placed on business model innovation and radical innovations that are new to the world. Not only are innovation activities new to a firm, but they are often non-compatible with the firm’s established practices and thus result in people rejecting such innovations (Markides, 2006). Kaplan (2012) challenged the notion of learning how to do disruptive innovation in retrospect and looking for repeatable best practices while it may be more appropriate to identify best principles which may include a disruptive approach to management itself. For this study, it means that technology innovation leaders need to be competent in making new innovations attractive based on their value and finding creative ways to overcome resistance.

3.4.2.5. Dynamic theory of strategy

Porter (1991:95) proposed his dynamic theory of strategy which claims that a chain of causality is important yet difficult to link to boundaries between exogenous and endogenous variables and that differences reported in literature are often not conflicts but differences based on different points in the value chain. Where the external change is rapid or continuous, analytical problems become very complicated since the value of past resources is continually depreciated or even negative. Strategy in one position does not determine the position in another and through innovation firms have considerable latitude in both influencing its environment and responding to it (Porter, 1998:120-122). For the technology innovation leader this implies dealing simultaneously with forces inside the firm itself and the external environment during innovation processes.

3.4.2.6. Economic value theories

Schumpeter (1942) proposed the dynamic economic growth theory which became known as creative destruction which suggests that technology innovation is a major reason for increased investments and business fluctuations through applications of new technology (Perez, 2009; Schumpeter, 1942). The work of Nobel laureate, Robert Solow (1974) also acknowledged technology innovation as a central driver of economic development and growth from which logic it can be argued that up to 80 percent of economic growth can be attributed to technology innovation (Lochner, 2011).

3.4.2.7. Innovator's dilemma

Innovator's dilemma theory (Christensen, 1997) relates to the observation that many firms are being destroyed because they failed to notice and react to game-changing transformations in their environments. They then found themselves unable to respond, transform and redirect the firm in time to integrate the new rules of the game. The way out of the innovator's dilemma is to change the game being played and adopt a new corporate bottom line in which innovation is a necessity, not an option (Denning, 2012). The implication for this study is that the technology innovation leader needs to influence innovation activities to master emerging rules of the game.

3.4.2.8. Innovation systems

Kotsemir, Alexander and Meissner (2013:4) referred to the Organisation for Economic Co-operation and Development's (OECD, 2013) definitions of innovation that were formulated in 1981 that referred to innovation as all "...scientific, technical, commercial and financial steps necessary for the successful development and marketing of new or improved manufactured products, the commercial use of new or improved processes or equipment, or the introduction of a new approach to a social service. R&D is only one of these steps". A systems perspective to these steps was observed by De Wet (1991) who conceptualised the illustration in Figure 3.6 to indicate how science and technology paradigms had shifted from research and development to a systems view of the management of innovation.

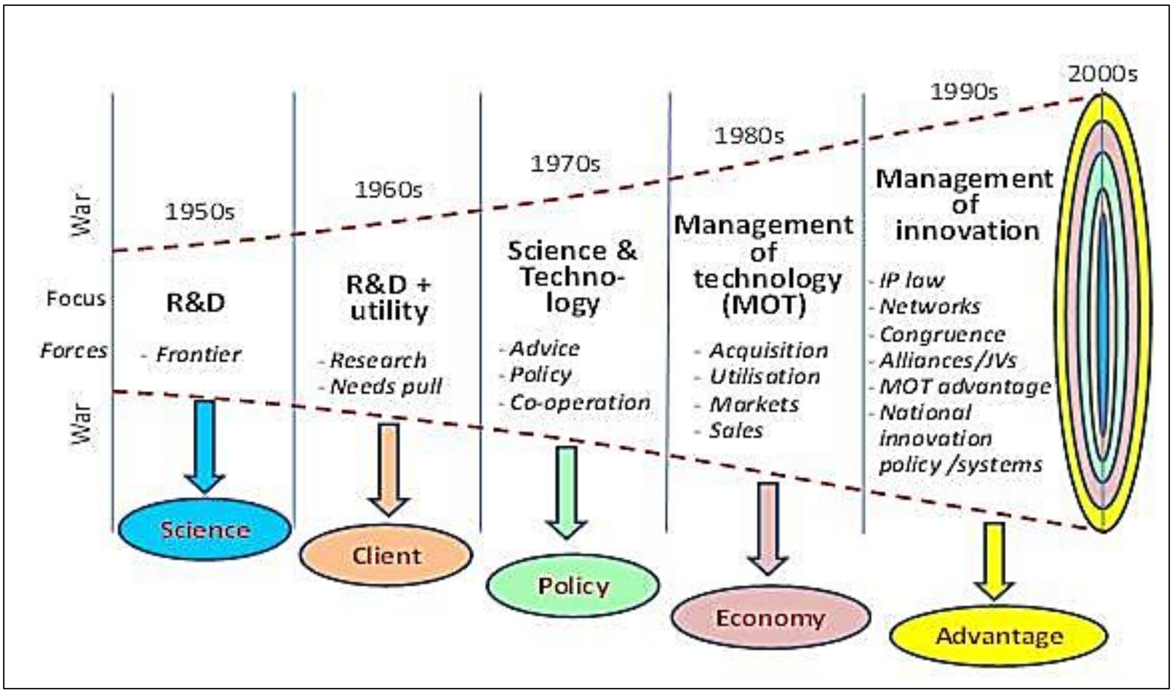


Figure 3.6: Science and technology shifts over 50 years

Source: Adapted from De Wet, 1991.

If value creation is to be achieved through innovation, it is argued that the technology innovation leader has to grasp that value equates to benefits that stakeholders associate with the innovation, such as competitive advantage, performance improvement, long-term survival (Anderson *et al.,* 2014), better practices, procedures, products/services, prosperity (Brynjolfsson & Hitt, 2000), rejuvenation of economy clusters, economic growth and turning possibilities and discoveries into economic reality (Perez, 2009).

3.4.2.9. Stakeholder theory

Stakeholder theory (Donaldson & Preston, 1995) has been advanced and justified in management literature based on its claim that stakeholders may be viewed as trustees of the firm without whose support the organisation would cease to exist, and they identify specific institutional types and interests being included as stakeholders. The technology innovation leader may have to consider stakeholder interests during technology innovation and this includes partners, co-creators and collaborators as stakeholders that were not included in the 1995 version of the stakeholder theory.

3.4.2.10. Systems integration theories

Systems integration concerns the fit among parts (Bruton & White, 2011:81) and various levels of systems integration can be distinguished, all of which may be areas in which the technology innovation leader may have to lead. Literature suggests three dominant perspectives of technology innovation that are not mutually exclusive:

i) The application of scientific knowledge for practical purposes, including machinery or equipment developed from this knowledge (Oxford Dictionary, 2009:954)

ii) An iterative process initiated by the perception of a new market and/or new service opportunity for a technology-based invention which leads to development, production, and marketing tasks striving for the commercial success of the invention (Garcia & Calantone, 2002:112); and

iii) A perspective emphasising both the practice and application of any of the applied sciences for practical value or industrial use (Grulke & Silber, 2001).

By combining the above perspectives, technology innovation can be seen as the process of turning ideas into reality and capturing value from them – and only if we can manage the whole process, is innovation likely to be successful (Tidd & Bessant, 2013). This is specifically true in technology innovations made possible by scientific knowledge and that result in value manifestation during the “second machine age” described by Brynjolfsson and McAfee (2014:1).

3.4.2.11. Technology functionality grid

Lochner (2011) and Van Wyk (2012) proposed a technology functionality grid to accommodate all possible technology innovation functions, all of which are accommodated in this study. The functionality of technology is clustered into nine basic functionality categories as indicated in Figure 3.7. Its original developers (Van Wyk, Karschnia & Olson, 2008: 61) also claimed that it supports a panoramic view of the entire technology landscape for planning and reporting purposes by presenting nine basic functionality categories. Technology innovation leaders may come from any one or more of the cells. The International Association of Managers of Technology (IAMOT) supports this framework, as presented in Figure 3.7, for use in research and education (Van Wyk, 2012).

		Action		
		Process	**Transport**	**Store**
Output	**Matter (M)**	Cell 1: Transforming substances	Cell 2: Moving substances	Cell 3: Holding substances
	Energy (E)	Cell 4: Generating energy	Cell 5: Transmitting energy	Cell 6: Keeping energy
	Information (I)	Cell 7: Composing information	Cell 8: Sending information	Cell 9: Saving information

Figure 3.7: Technology functionality grid

Source: Adapted from Lochner, 2011:52.

3.4.2.12. Technology innovation theories

Whilst technology has been defined in Section 3.2 for consistent use throughout this thesis, other definitions reveal different perspective and theoretical nuances that may relate to competencies deemed to be required by technology innovation leaders for successful technology innovation. The technology innovation leader may interact with others that have different views about innovation. Contributions to standardising terminology in the technology management and innovation fields have been fragmented and are not yet shared by all affected constituencies (Van Wyk, 2012). Innovation definitions tend to vary in the words that they use "but they all stress the need to complete the development and exploitation aspects of new knowledge, not just its invention" (Teece, 2010; Tidd & Bessant, 2013:18).

Some may emphasise aspects of technology innovation more than others such as the physical manifestation when technology is defined as the application of scientific knowledge for practical purposes in the form of machinery or equipment developed from this knowledge (Oxford Dictionary, 2009:954). While this definition appears to be brief and clear, it fails to acknowledge socio-economic and competitive drivers of technology innovation as discussed in Chapter 1 of this thesis. Innovation scholars Garcia and Calantone (2002:112) contextualised their extensive literature review to suggest that the 1991 OECD definition best captures technological innovation as "...an iterative process initiated by the perception of a new market and/or new service opportunity for a technology-based invention which leads to development, production, and marketing tasks striving for the commercial success of the invention".

3.4.2.13. Technology innovation typology

Technology innovation takes place in different novelty level configurations of components as presented in the innovation typology presented in Figure 3.8 (Smith, 2010). This study does not study each or exclude any possible configurations but rather accommodates leader involvement in one or more of the identified categories.

		Components	
		Reinforced	**Replaced**
System	Changed	Incremental innovation	Radical innovation
	Unchanged	Architectural innovation.	Modular innovation

Figure 3.8: Innovation typology

Source: Adapted from Abernathy and Utterback, 1978.

3.4.2.14. Technology S-curve

Technology innovation can spur the development of technology-enabled products, services and production technologies that give rise to new industries and change frontiers and conditions based on lower cost input, energy, material and infrastructure which often extends the reach, speed and reliability of offerings (Perez, 2009).

The well-known technology 'S-curve' theory (Smith, 2010) suggests that new technologies will have different levels of yield over time and eventually reach the end of the curve where more engineering effort would not yield major advantages as happened at the beginning stages of the curve. This study accommodates leader involvement across the entire curve, rather than excluding certain positions from the study.

3.4.2.15. Technology zone of influence theories

There was a time when technical innovation could be clearly separated from administrative innovations and technical innovations meant products, processes and technologies used to produce products and render services directly related to the basic work activity of an organisation (Gopalakrishnan & Damanpour, 1997:19). In 2014 Massachusetts Institute of Technology (MIT) professors Brynjolfsson and McAfee (2014:1) released their book on what they call "the second machine age", suggesting that the technology required for generating new technology innovations have become accessible to non-technical people that were previously alienated by the technology fraternity. The researcher compiled Figure 3.9 to illustrate that this study acknowledges the multi-dimensional application areas in which technology innovation takes place.

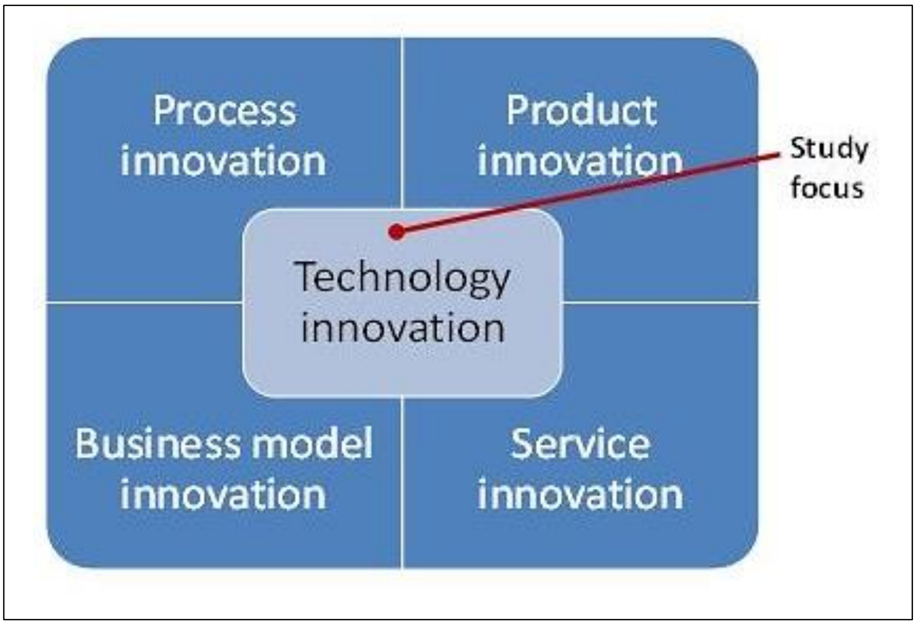


Figure 3.9: Research scoping: study focus

Source: Adapted from Smith, 2010.

3.4.2.16. User involvement theory

The user involvement theory of Schweitzer, Gassmann and Rau (2014:155) built on the co-creation literature of previous scholars. It is specifically discussed here because of the critique by Schweitzer *et al.* (2014:155) that users had always been integrated into the innovation process via traditional market research, but that previous authors had failed to consider the effect that technology maturity of users might have on innovation success. They found that new forms of user integration through information and communication technology allow greater opportunities for user involvement in innovation.

Users with high technical skills were more likely to produce ideas that are technically feasible. Trend-aware users and technically-innovative users were more original with their contributions, while ethically reflective users' contributions tend to come up with ideas that have a positive impact on society. This study interprets these findings as support for the technology connectedness and stakeholder alignment identified as technology innovation leader capability clusters deemed to be required for technology innovation success.

3.5. REVIEW OF INNOVATION PROCESSES

As mentioned frequently in this thesis, the identification of technology innovation leader competencies deemed to be required for successful technology innovation requires clarity on the innovation process to be used that would indicate what the leader should be competent at (Denti & Hemlin, 2012), as is further discussed in Section 3.6. A selection of innovation process models or perspectives found in innovation management literature is presented below to serve as basis for subsequent discussions.

3.5.1. A generic process model for innovation

The generic process model for innovation as indicated in Figure 3.10 is based on two major phases of work, namely an R&D process and a commercialisation phase that are collectively underpinned by seven steps (Smith, 2010:105). According to this process model, innovation starts with a new insight or a research-based breakthrough, followed by development of a concept which is taken further through design, followed by market evaluation, production engineering, market or pilot testing and ends with full-scale manufacturing after the idea had successfully been led through a sequential series of steps.

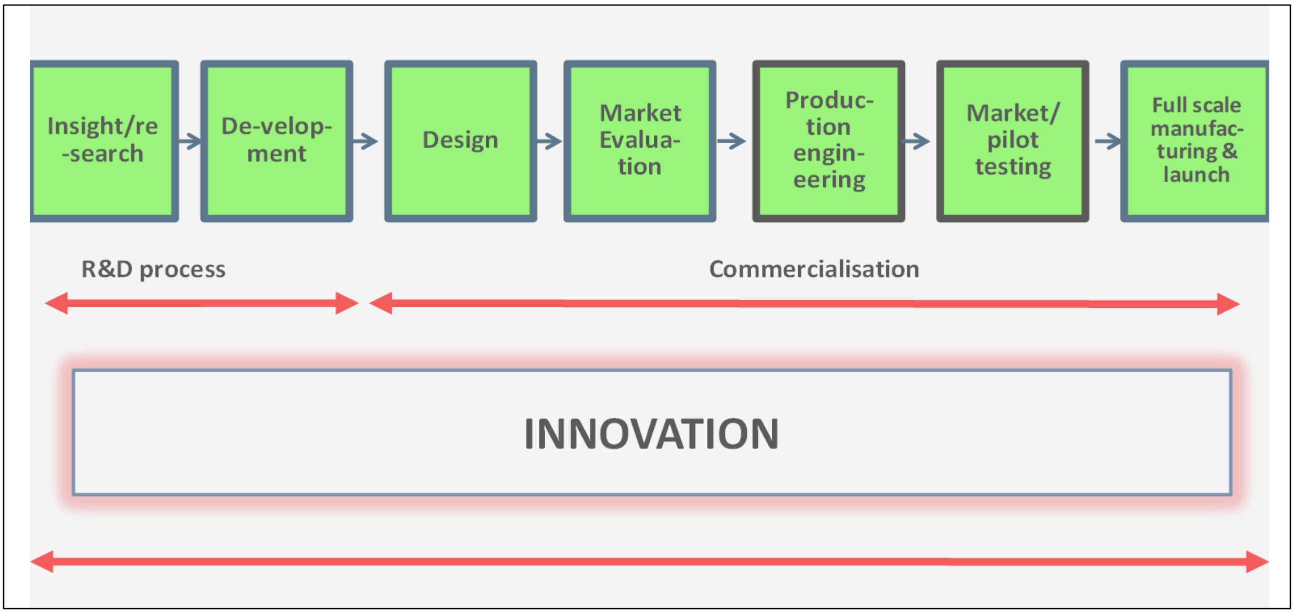


Figure 3.10: Generic model of the innovation process

Source: Smith, 2010.

3.5.2. Technology push model

Figure 3.11 below shows a different flow of logic from the previous process by starting with a new scientific discovery that implies new possibilities for technical applications. The leader follows a process of designing, developing, and producing technologies that the sales and marketing functions will make attractive to prospective buyers (Rothwell, 1994).

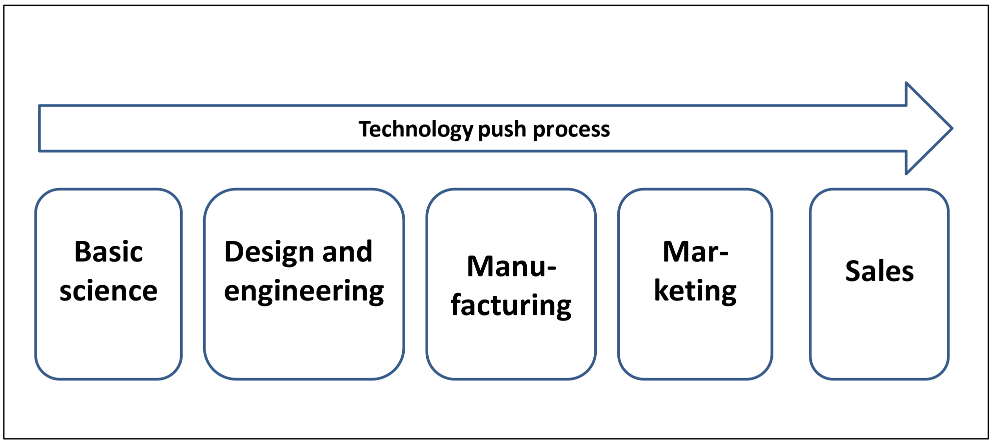


Figure 3.11: Technology push process

Source: Rothwell, 1994.

3.5.3. Demand pull process

Figure 3.12 below implies that a technology innovation leader leads the innovation process by starting with a known or assumed market need before applying technology towards addressing the need. Producing the technology and selling it to prospective buyers remain the concluding steps.

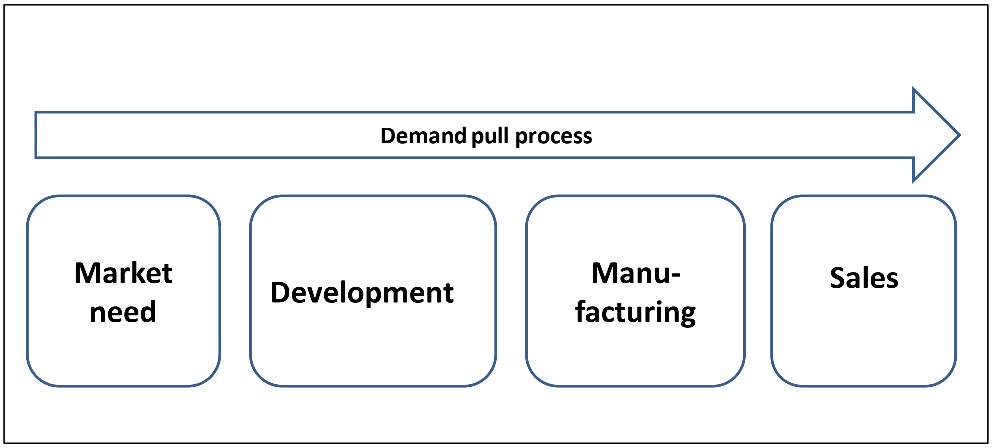


Figure 3.12: Demand pull process

Source: Rothwell,1994.

3.5.4. Coupling process

The coupling process illustrated in Figure 3.13 below combines technology-push and demand-pull forces. The technology innovation leader starts the coupling process with either a new need or a new technology and then follows fairly similar process steps as in the earlier two models to end up with a pre-produced product being sold in the marketplace.

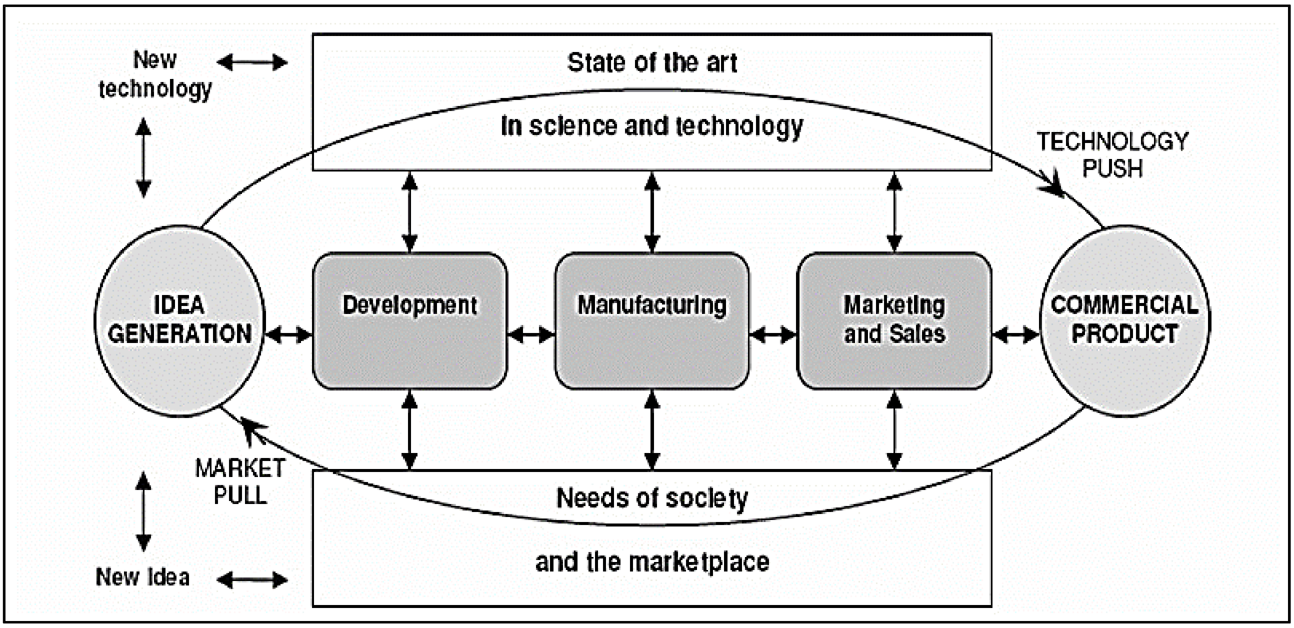


Figure 3.13: Coupling process

Source: Adapted from Du Preez & Louw; 2008; Rothwell, 1994.

3.5.5. Integrated process

The integrated process illustrated in Figure 3.14 below incorporates competitive forces and the technology innovation leader leads the process in such a way that internal efficiencies become important considerations for getting a product into the market faster and at more beneficial terms than competitors.

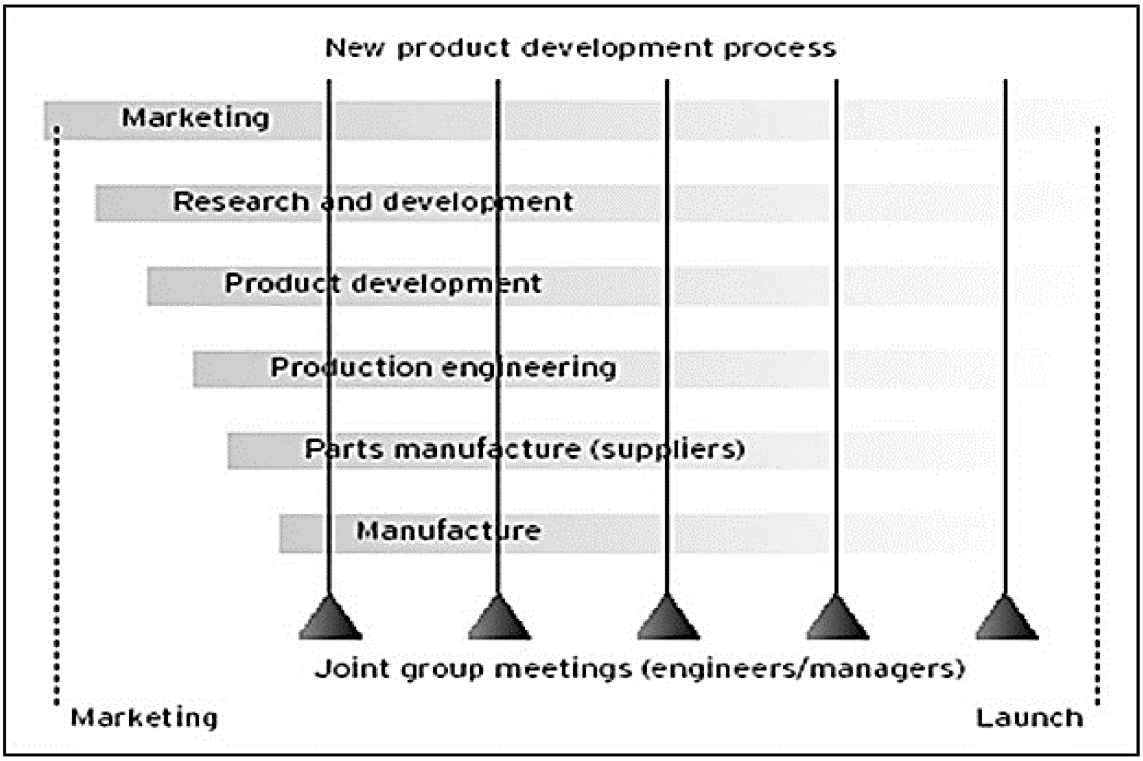


Figure 3.14: Integrated process

Source: Rothwell, 1994.

3.5.6. Open innovation process

In an open innovation process, such as illustrated in Figure 3.15 below, the technology innovation leader leads a process that does not only rely on internal knowledge, ideas and contributions, but also opens up the technological innovation process to external sources.

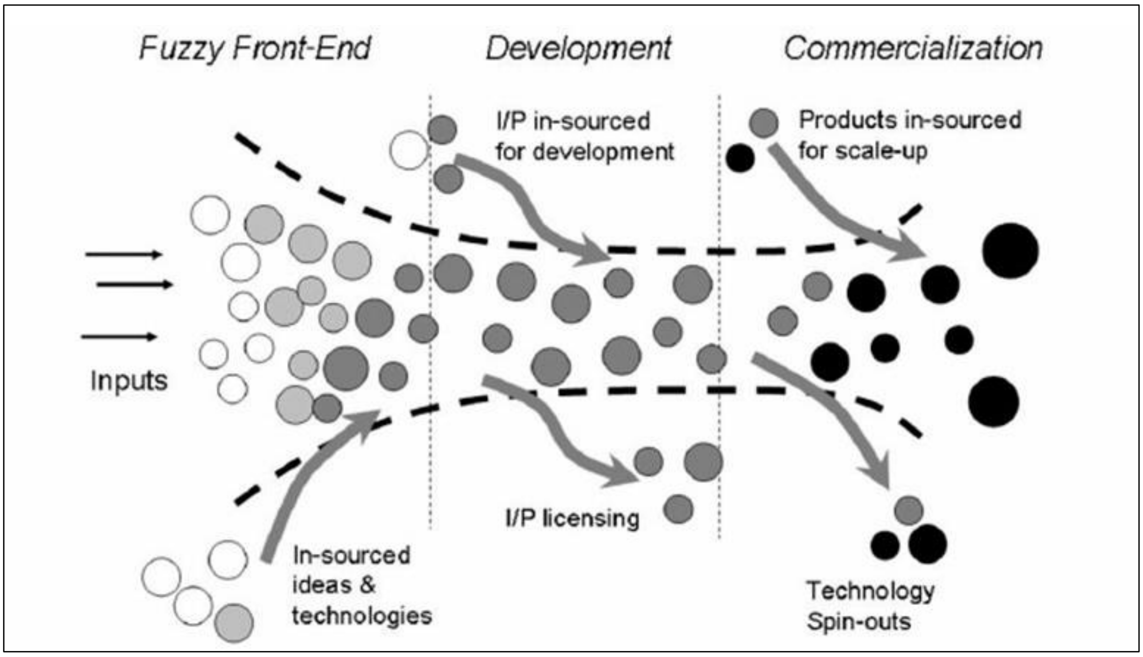


Figure 3.15: Open innovation process

Source: Docherty, 2006.

As described in the introduction to this chapter, open innovation has rendered much of the traditional closed system R&D paradigms obsolete. The seminal work of Chesbrough (Heim, 2010), who introduced the concept of open innovation, can be summarised (Tidd & Bessant, 2013:313) in the following six principles:

i) Not all the smart people work for one firm;
ii) External ideas can help to create value, but internal R&D should claim a portion of their value;
iii) Business model innovation can yield better results than being first into the market;
iv) Making the best use of both external and internal ideas increases the probability of success in innovation;
v) Firms should profit from others' use of their intellectual property (IP) and should also use other people's intellectual property to enhance the firm's business model;
vi) The role of R&D should be broadened to include not only knowledge generation, but also knowledge of opening.

3.5.7. Fugle process

Du Preez and Louw (2008:11) presented the Fugle model in Figure 3.16 based on bringing two metaphors together in the innovation process, namely the funnel and the bugle, to overcome the inadequacies of other processes which they summarised as follows:

> *Most innovation process models evaluated focus mainly on the funnel part of the innovation process (i.e. identifying and filtering new ideas and concepts). Further, they mostly address product innovation as opposed to service companies that have less tangible products (e.g. insurance companies). These models also neglect or totally exclude the exploitation part of a new innovation, i.e. to successfully exploit the innovation in different markets and application areas (including exploitation of different business models for the enterprise). This is important since an innovation should at the end generate more value to the company than the cost that it is associated with.*

For the technology innovation leader, these revelations introduce an entirely different dynamic when compared to the previous processes by placing emphasis on integration of processes and the focus on value means throughout the innovation process.

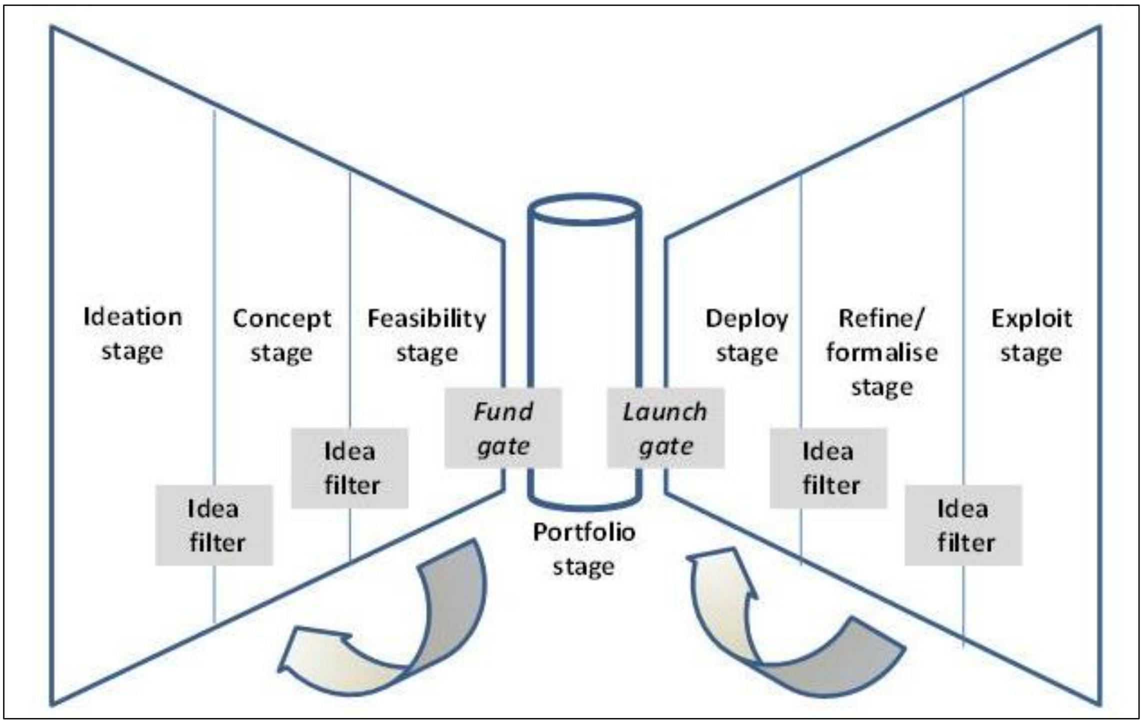


Figure 3.16: Fugle process

Source: Adapted from Du Preez and Louw, 2008: 12.

3.5.8. Network spiral process

The network spiral process, illustrated in Figure 3.17 below, introduces another complex variable that should inform how the technology innovation leader leads the technological innovation process based on the accumulation of knowledge over time.

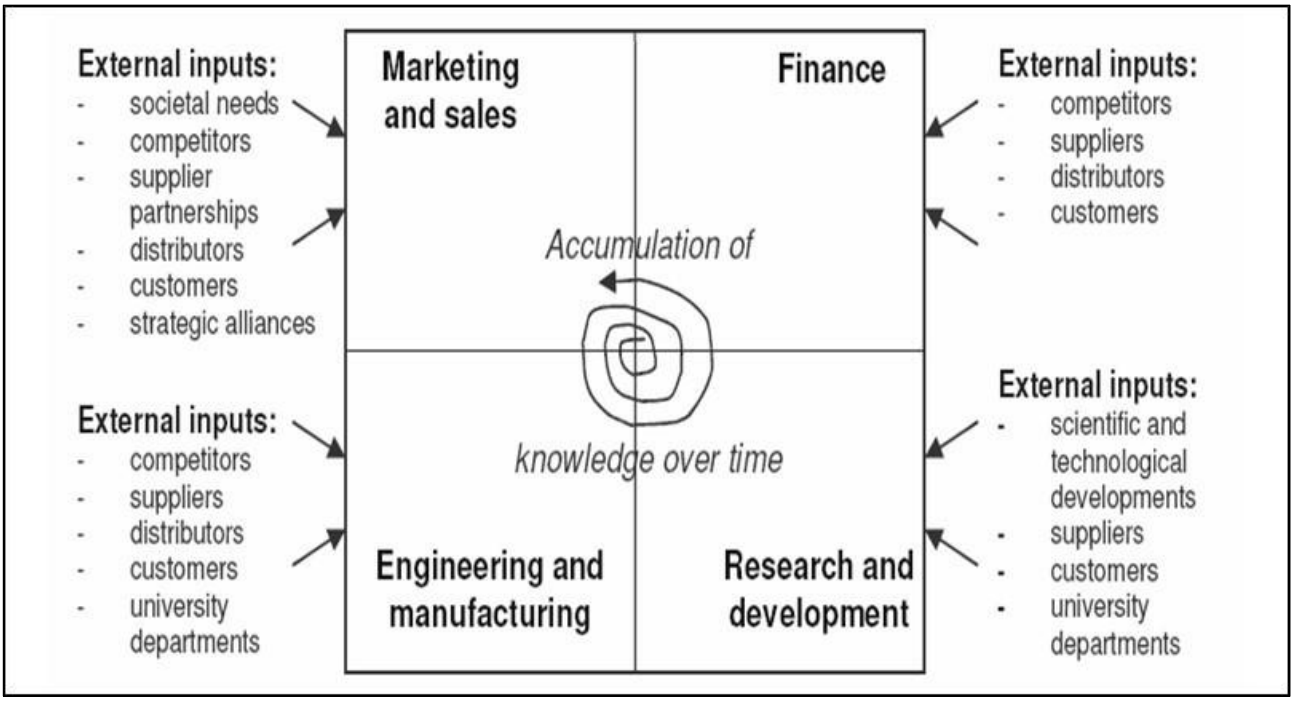


Figure 3.17: Network spiral process

Source: Trott, 2005.

3.5.9. Stage-gate process

As illustrated in Figure 3.18 below, the technology innovation leader starts the technological innovation process by soliciting ideas, typically related to unmet customer needs, before embarking upon a sequence of the conversations with go/no-go decision points in between.

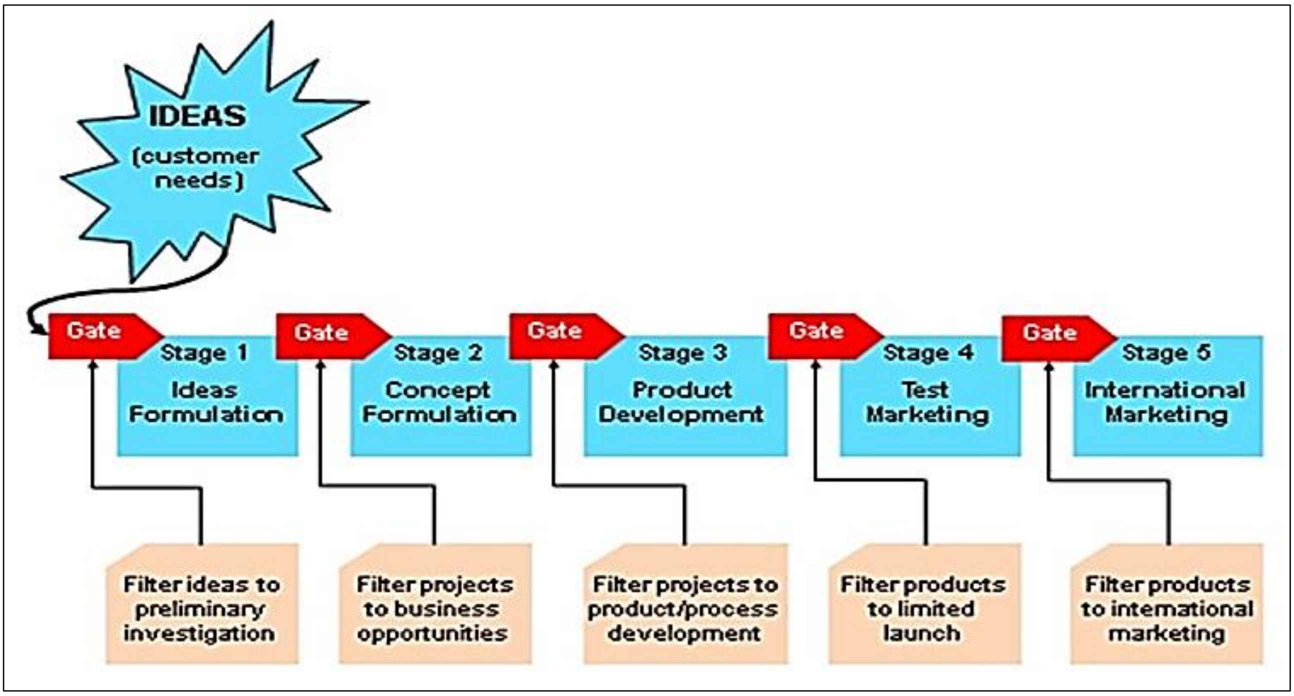


Figure 3.18: Stage-gate process

Source: Adapted from Cooper,1994; 2000.

3.5.10. Presencing process

Presencing or Theory U, as it is sometimes referred to (Scharmer, 2009), is used in this thesis to illustrate the isolated benefits, contradictions and limitations of various technological innovation processes available to the technology innovation leader. The presencing process shown in Figure 3.19 suggests that the technology innovation leader should lead team members through essentially three phases involving changes in: (i) how the need for innovation is observed; (ii) how members evolve from intellectual to emotional and conscious commitment; and (iii) how emerging new possible futures are being pursued.

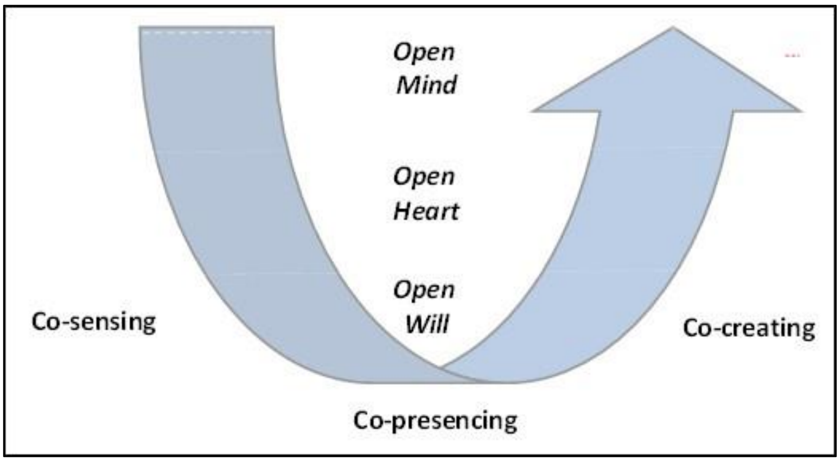


Figure 3.19: Presencing process

Source: Adapted from Scharmer, 2007.

3.5.11. Design management

'Design' can be defined as the conscious decision-making process by which information (an idea) is transformed into an outcome, be it tangible (product) or intangible (service) (Von Stamm, 2009:17). 'Design' has traditionally been associated with a person who is involved in both the design and production of an object (Von Stamm, 2009). An example of a design specification is a patented bracelet-chain registered to a person's name, which describes the elements and configuration of the bracelet, so that it can be recognised as unique and protected as intellectual property (Freeman, 1883).

With the outset of the Industrial Revolution, the design and production activities became separated to allow for specialisation in either 'design as art' or 'design as engineering' (Von Stamm, 2009). Further specialisation followed, resulting in confusion about where exactly the boundaries should be between design, new product development and innovation (Von Stamm, 2009:18). Decision-making about design relates to consciously comparing and selecting the best possible solution, and so managers became involved who were trained in analytical fields while designers were trained to deal with projects that involved unfamiliar concepts, that are predominantly visual rather than verbal, involve fuzzy problems and high levels of ambiguity (Von Stamm, 2009:18).

Design management implies planning, organising, staffing, directing and controlling design (Koontz & O'Donnel, 1976:70). While the authors acknowledged that not all managerial activities could be placed into these categories because managerial functions tend to coalesce, they claimed that "planning is a prerequisite to all tasks of management". This statement implies that goals had been set and plans had been made that were communicated and understood, and that "jobs have been set up to fit in with them" (Koontz & O'Donnel, 1976:379).

The underlying logic suggests that design processes need to be controlled against certain standards, and that managers would know best to guide designers towards either rational or normative standards (Barley & Kunda, 1992). The interplay between broad cultural and economic forces may have underwritten these choices over time, but also appears to have "constrained the collective imagination of the managerial community by dichotomising the range of acceptable images of organising" (Barley & Kunda, 1992: 392). According to Barley and Kunda (1992:394), the power of any social-scientific theory lies in its capacity to not only explain the past, but in its ability to anticipate the future through establishing appropriate paradigms.

The separation of tasks that previously constituted design, is clearly associated with the industrial age way of doing things and clearly in contrast with the emerging innovation age practices of liberating people to create newness, as suggested in Figure 3.20.

Design thinking appears to be one way of closer integrating design and management activities, as indicated in Figure 3.20.

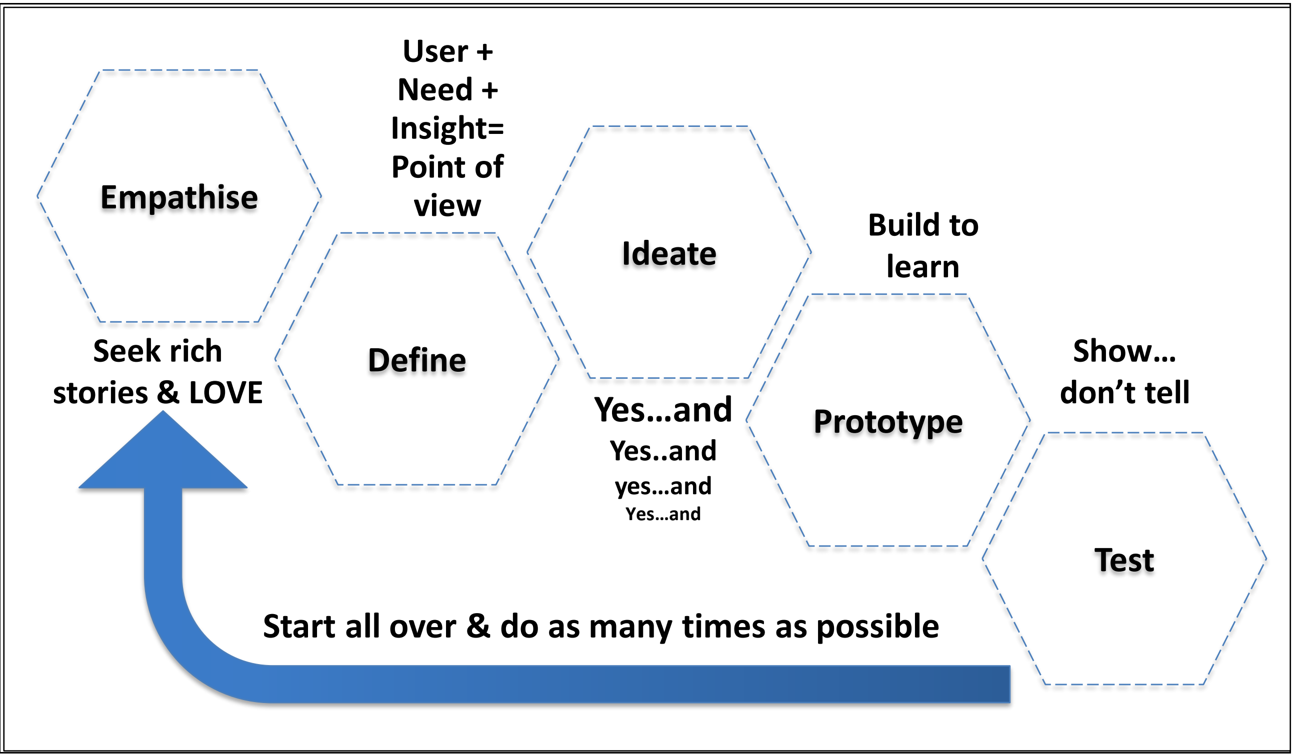


Figure 3.20: Design School's thinking modes

Source: Adapted from Kovalskys, 2014.

In anticipation of changes in the world and innovation, Von Stamm (2009: 484) claimed that "more and more organisations realise that innovation requires an approach that touches all the different asppects of an organisation and that creating an innovative organisation is fundamentally, about a company's culture and leadership". Design thinking provides a structured way of integrating design and management considerations related to innovation once companies have worked out exactly what it means and acquire the skills necessary to do it successfully (Von Stamm, 2009:484).

3.5.12. New product development process

As indicated in the previous section, it is not always clear where exactly the boundaries should be between design, new product development and innovation (Von Stamm, 2009:18). However, companies wanting to become more innovative, "will almost certainly include in their thinking,a new product development process" (Von Stamm, 2009:49).

For the development of new products to be successful, the process must simultaneously achieve three sometimes-conflicting goals, namely: (i) maximising the product's fit with customer requirements; (ii) minimising the development cycle time; and (iii) controlling the development cost (Schilling, 2010:239). Ulrich and Eppinger (1995) viewed new product development as a set of activities that starts with the perception of a market opportunity and ends in the production, sales and delivery of a product.

As a recognised thought leader in new product development, Cooper (1990; 1994) proposed the stage-gate process discussed above for use as a road map in developing new products or, product innovation (Cooper, 2000). During a later best practices study, he found that project selection and project prioritisation had been the weakest areas of new product management and that the stage-gate process had not been designed to make wrong products successful, when new product selection should have been based on strategic and portfolio considerations (Cooper, 2000).

The emphasis was on doing things right, which he reviewed to emphasise the necessity of linking new product innovation to a firm's technology strategy to ensure doing the right projects and doing them right (Cooper, Edgett & Kleinschmidt, 2000:38). Following another benchmarking study to answer the question if stage-gate processes really work in an 'idea-to-launch model', the study found that "there is a lack of hard evidence as to what governance structure works best and just what its impact is, if any" (Cooper & Edgett, 2012:43). This observation may be interpreted as yet another admission that the management profession is losing its ability to control complex systrems in a world of increasing volatility and uncertainty.

In another review, Cooper (2008) claimed that the stage-gate process had become a popular system for driving new products to the market, but that there were many misconceptions and challenges in its use. These included: "governance issues, over-bureaucratizing the process, and mis-applying cost cutting measures such as Six Sigma and Lean Manufacturing in product innovation", for which 'gates with teeth' are proposed, or what could be interpreted as more control (Cooper, 2008:2). New variations of the stage-gate process are presented with more flexibility and scaleability for different project-environments, including new features, such as spiral development and simultaneous execution, and better decision-making practices, such as scorecards, success criteria, self-managed gates, electronic and virtual gates and integration with portfolio management (Cooper, 2008:2).

A different perspective came from Takeuchi and Nonaka (1986), who compared new product development to a rugby team where there is an infinite variety of possible tactics and success is about blending team talents in the best possible way, as opposed to running a relay as may be implied by other authors mentioned.

3.5.13. Section synthesis

The reviews of innovation process models conveyed their respective particular sequences of activities, suggesting that certain process steps have to be addressed before a next step can commence. The implication for technology innovation leaders is that leader competencies being applied in a process are determined by the particular process model selected. Such a predetermined flow seems to be in direct conflict with innovation theories discussed in the previous section. For example, Rosenfeld *et al.* (2011:197) claimed that structured linear innovation process models may be suitable for "tame" innovation problems, but inadequate for "wicked" innovation problems that present the innovation leader with technical, human and business challenges that often pose incomplete, contradictory, and changing requirements that require iterative thinking.

The review of different innovation processes also revealed considerable similarities and differences resulting in apparent overlaps and confusion that may impact on the competencies required. Limitations of control-centred processes were revealed and evidence presented of increasing significance of flexibility and customisation of innovation processes to achieve successful innovation. These perspectives support the views of Von Stamm (2009:49), that new insights into processes for innovation suggest that "a structured process is often not sufficient" and that "the behaviours of people would have to change alongside".

The answer to research sub-question SRQ 1.1 is therefore inconclusive by not favouring any particular model, but accepting that the solution might be found in a newly-configured innovation process. The next section discusses an alternative innovation process to be considered for identifying leader competencies, after confirming that a process-approach to the identification of technology innovation leader competencies for succesful technology innovation was still required.

3.6. USING INNOVATION PROCESS TO IDENTIFY LEADER COMPETENCIES

The conceptual model in Chapter 1 anchored the identification of leader competencies in the process used to turn ideas into technology solutions. This section reiterates that technology innovation takes place through a process and that technology innovation leaders' competencies are applied across the process, irrespective of the number of phases or stages proposed by different process models.

3.6.1. Leader competencies required across innovation process

Following their review of 30 empirical studies where leadership was the independent variable and innovation the dependent variable, psychologists Denti and Hemlin (2012:1-2) concluded that "leaders are an essential element in the promotion of organisational innovation" where innovation is the result of activities performed at different levels of the organisation and its external world. Innovation leaders need to be competent across a dual process because they "construct the environments that favour creativity and ultimately innovation" and because they "manage the strategic innovation goals and activities of their organisations" (Denti & Hemlin, 2012:2).

While Denti and Hemlin (2012:13) acknowledged that the leader has to "provide a structure for the innovation process", they suggested further research into how "the innovation process" interacts with leaders' efforts which endorses the view that the process-related contributions from different authors tend to differ and represent non-compatible and even conflicting views (Buijs, 2007).

Section 3.2.5 of this thesis defined innovation as "a process of turning ideas into reality and capturing value from them – and only if we can manage the whole process, is innovation likely to be successful" (Tidd & Bessant, 2013:21), which implies leader competencies across the entire process used for technology innovation. Too often technology innovation is portrayed by theorists as linear and sequential which can be challenged by pragmatists such as Keldman (2016:1) who claimed that "...most people writing about innovation have never 'lived' their theory".

Based on the preceding discussion the innovation process to be used for identifying technology innovation leadership competencies need to accommodate the notion that technology innovation can start at different innovation points and evolve in different sequences or iterations.

3.6.2. Process requirements for competencies identification

The conceptual model for this study in Chapter1 indicates that the identification of leader competencies had to be based on the innovation process required. The previous section proposed that an innovation process be used that can start at different points and evolve in different sequences or iterations. If innovation starts with an idea and concludes with its implementation or adoption, a mere aggregation of the theories presented above cannot be assumed to represent a coherent integrated holistic view of what successful technology innovation entails (Tidd & Bessant, 2013).

Table 3.4 provides a summary, followed by a discussion of each of the additional process perspectives to be accommodated by the innovation process to be selected as basis for identifying technology innovation leader competencies that would minimise constraints and allow for innovation.

In the context of this study 'constrained' means "severely restrict or limit" which are terms for which the antonyms are "freedom" and "ease" (Oxford Dictionary, 2009:190). 'Innovation' is defined as the introduction of new ideas or products and synonyms include change, upheaval, alteration, reorganisation, restructuring, novelty and departure (Oxford Dictionary, 2009).

A "breakdown in innovation management" is one of four major categories of root causes of the start of a "material reversal in the growth fortunes of an organisation". (Ungerer, Ungerer & Herholdt, 2016:311). An innovation management breakdown is within management's control and defined as "...failure to achieve desired or required returns on investment in new products, services and business development" because of internal "...systemic inefficiencies or dysfunctions" in processes that fail to update current offerings and create new ones (Ungerer *et al.* 2016:312). Ungerer *et al.* (2016:312, 317) also pointed out that "innovation management is a fragile and sensitive process..." influenced by imbalances in "a mix of investments" and by implication the "portfolio of experiments and prototypes".

Table 3.4: Summary of process perspectives to identify competencies

Perspective	Source	Technology innovation leader implications
Process model constrains for competencies identification	Oxford Dictionary, 2009	Avoid being constrained by any particular process model.
Process breakdown in innovation	Ungerer, Ungerer & Herholdt, 2016	Contribute to process and systems efficiency and innovation portfolio.
Process as dynamic complexity	Buijs, 2007; Elkins & Keller, 2003; Hoque, 2013; Rosing, Frese and Bausch, 2011; Tidd & Bessant, 2011; 2013.	Allow for flexible switching between exploration and exploitation activities and between different leadership roles in a holistic process, including boundary spanning.
Process as compliance	Suriyamurthi, Velavan and Radhiga, 2013	Include both implementation of ideas and generation of new ideas.
Process as creation through knowledge exchange	Tidd & Bessant, 2013; Technovation, 2014	Accommodate knowledge flow across process boundaries.
Process allowing iterative thinking	Rosenfeld, Wilhelmi & Harrison, 2011; Beinecke, 2009	Allow iterative thinking in innovation process for complex problems
Process perspectives on task partitioning theory	Von Hippel, 1990, 1976	Avoid negative effects of task partitioning
Process as agility	Worley, Williams & Lawler, 2016	Make management processes flexible and fast to accommodate change.

Process as dynamic complexity is a view held by Rosing, Frese and Bausch (2011:956) who claimed that research has neglected the complex nature of innovation processes (Buijs, 2007), that lead to changing requirements within innovation processes. They insisted that innovation processes should allow for exploration and exploitation as well as "...flexibility to change between those two activities". Their ambidexterity theory of leadership for innovation specifies two complementary sets of leadership behaviour that foster exploration and exploitation in individuals and teams. Paradoxical dynamic switching between roles, such as sponsor and critic, "seems to be necessary for innovation success" (Rosing *et al.,* 2011:970. The dynamic complexity of the innovation process suggests that the technology innovation leader has to balance repetitive processes (Hoque, 2013) with contextually customised processes that avoid viewing innovation as a simplistic process organised around invention as focus, ending up with inventions that people do not want because important considerations had been left out (Tidd & Bessant, 2011:23). Elkins and Keller (2003), who were early contributors to the conversation on leader behaviours for innovation, found boundary-spanning activities (also known as gate keeping) of the leader in R&D environments to be very important for success. Their description of such behaviours refers to institutional, as well as functional boundaries.

Processes can be interpreted as compliance mechanisms such as the innovative work behaviour (IWB) model of Suriyamurthi *et al.* (2013) who claim to remedy known process shortcomings through compliance to their four stages of exploration, generation, championing and application. Unfortunately, the IWB model is not explained in terms of its origins, leader behaviours or scientific grounding. One of the most successful technology innovation leaders being quoted in popular media, is South African born space technology entrepreneur, Elon Musk, who prefers the application of first principles in innovation rather than following established proceses based on the past, stated:

> *I don't believe in process. In fact, when I interview a potential employee and he or she says that 'it's all about the process', I see that as a bad sign...The problem is that at a lot of big companies, process becomes a substitute for thinking. You're encouraged to behave like a little gear in a complex machine. Frankly, it allows you to keep people who aren't that smart, who aren't that creative.* (Musk, 2017)

Process as creation through knowledge exchange is about creating new possibilities through combining different knowledge sets that are stored in the minds of people as "tacit knowledge", based on their prior experiences or come from a search process where meaning is codified in such a way that others can access it (Tidd & Bessant, 2013:39 &189). Explicit knowledge is objective and can be untied from the situation by which it was acquired. This knowledge is related to the rational, theoretical, and scientific activities in a positivistic sense (Technovation, 2014) and may bring diversity of views to innovation processes to stimulate new insights (Rosenfeld *et al.,* 2011).

Not every part of decision-making can be done on a linear basis (Manual, 2013). Innovation in wicked problem areas require non-linear processes of an iterative nature in which it is possible to "...jump back and forth between all activities" and to add more people to the team as practitioners, leaders, or stakeholders where needed (Rosenfeld *et al.* 2011:201). It is often the social complexity of problems as well as their technical difficulties that require new leadership skills and "...a dynamic process that emphasizes the need for quality, flexibility, adaptability, speed, and experimentation" (Beinecke, 2009:2).

Process perspectives based on task partitioning theory applies when innovation projects are "partitioned" into smaller tasks and given to different people that create barriers between tasks affecting project outcome and task efficiency due to implications of problem-solving interdependence among tasks (Von Hippel, 1990:407). Parts of an innovation process may be highly interdependent, such as design, build, marketin and -R&D, interdependence of tasks can be predicted and task specifications adjusted and/or barriers to problem-solving across task areas can be reduced. Von Hippel (1990) claimed that the core function of many innovation projects includes the generation of new information which requires problem-solving beyond self-imposed task boundaries. Innovation tasks are scheduled and allocated on "the assumption" that when members focus on their own tasks, "their output will properly mesh with the output of others to comprise the total intended project output" (Von Hippel, 1990:408). To avoid working from assumptions, innovation tasks may be allocated in "a way that never isolates development" as a separate task because "task partitioning is in fact a process variable" (Von Hippel, 1990:408). Von Hippel (1990) expressed concern that innovation tasks are allocated not based on problem-solving or information interdependence, but "on the basis of assumed economies of specialisation", for example that "All electrical design work will be done by group A"; "All marketing research studies will be done by group M" (Von Hippel, 1990:410). Boundary spanning becomes important and can be accomplished through the appointment of a gatekeeper to take on the role of passing information between players or the introduction of interventions such as appointing an "integrating group", using tools and facilitating problem-solving interaction across boundaries (Von Hippel, 1990:412). Von Hippel (1990) claimed that where boundaries are placed between innovation tasks, they can have unintended or negative consequences for project outcomes and task efficiency due to associated changes in the problem-solving inter-dependence among tasks.

Agility in innovation processes need to accommodate flexibility and speed as emphasised by Worley *et al.,* (2016) who argued that management processes help management to execute strategy and exercise capabilities amidst change when needed. Worley *et al.* (2016:1) claimed that management processes tend to be designed to align resource allocations with strategy, to apply "plan-do-check-act" logic and support and align with other management processes. In a fast-changing environment, however, fast and flexible management processes are required that align around purpose and outcomes, focus on effectiveness more than efficiency, accept a wide variety of inputs, allow adjustment of cycle times to fit the market rhythm, are simple to explain and involve wide sharing of relevant information and transparency.

From the preceding discussion two observations can be derived. Firstly, it becomes clear that the innovation process is, indeed, very complex" and also "quite different from the normal way of 'getting things done'" which makes talking about innovation as a single process misleading.

> *The innovation process model is like an inflatable lifebelt. It is useful for top management to check the quality of the lifebelt regularly. If there are punctures in the lifebelt, it cannot do its job properly. Of course, you can add more compartments to your lifebelt (each of the five stages form their own compartment and the gates act as pressure valves between the compartments).*
>
> *As a result, a puncture remains contained within one compartment. But too much control, in other words too many compartments (all stages and gates and also all activities plus 'mini-gates' within a stage), will make the lifebelt too heavy and impossible to use. (Buijs, 2007:209).*

Secondly, it appears that some skills are relevant across multiple process models. Dyer, Gregersen and Christensen (2009:1) found in most innovative companies studied, that executives feel responsible for facilitating the innovation process through five knowledge-related "discovery skills", namely: (i) associating; (ii) questioning; (iii) observing; (iv) experimenting; and (v) networking (Dyer *et al.,* 2009:2). No sequence is proposed and it may thus be argued that in practice, a technology innovation leader may not have to choose a particular technology innovation process upfront, but rather make provision for different bundles of process activity that could fit different process models.

The application of deconstruction theory is discussed next as a possible alternative approach to identify leader competencies that may be applicable for different process models.

3.6.3. Application of deconstruction theory for a different process perspective

Deconstruction theory is "the study of literature or philosophy which says that a piece of writing does not have just one meaning". It is the "analytic examination of something (as a theory) in order to reveal its inadequacy" or to "discover its true significance" (Merriam-Webster, 2016).

Each of the innovation process models presented above suggests boundaries between innovation tasks that present boundary challenges for the technology innovation leader that may result in unintended consequences affecting innovation success (Von Hippel, 1990). Considering potentially conflicting and contradicting competency requirements of the different process models discussed above, deconstruction theory offers an alternative to "...that oft-glossed over, but extremely important step that sits between observation (data gathering) and our design insights" (Baty, 2009:1). According to Steyn (2012:74), postmodernists emphasise a transition from the traditional controlled economy to the modern immediate economy where "...knowledge workers construct and deconstruct meaning according to shifting individual and organisational contexts".

Based on the perspectives presented, deconstruction is applied to allow for "...breaking observations down into component pieces..." and for "re-sorting, rearranging and otherwise moving your research data, without fundamentally changing it. This is used both as a preparatory technique, i.e. as a precursor to some other activity" (Baty, 2009:2). In this case, the results of the deconstruction serve as basis for the identification of technology innovation leader competencies deemed to be required for successful technology innovation.

Baty suggested that synthesis can take place at a later stage in the research process to allow for "...drawing together concepts, ideas, objects and other qualitative data in new configurations, or to create something entirely new" (Baty, 2009:3). Such a re-construction has ontological implications in relation to the nature of knowledge of the world held by the constructionist (Bryman & Bell, 2011:22).

> [Constructivism] *...asserts that social phenomena and their meanings are continually being accomplished by social actors ... and that they are in a constant state of revision ... and that researchers' own accounts of the social world are constructions. In other words, the researcher always presents a specific version of social reality, rather than one that can be regarded as definitive.* (Bryman & Bell, 2011:22)

Weber's *Verstehen* approach to interpretivism, "a term given to a contrasting epistemology to positivism" suggests that causal explanation is undertaken with the "...interpretive understanding of social action" and can be understood "only through understanding the meaning of the concept for those involved in this form of social action" (Bryman & Bell, 2011:16-17).

Constructive reflexivity in management research allows the researcher to "challenge existing conventions about how language is used to represent reality and invites the deconstruction of texts in order to reveal a narrative logic..." and "entails the researcher questioning his or her own taken-for-granted beliefs and accepting that there will always be multiple valid accounts of a research project" (Bryman & Bell, 2011:701).

In practical terms, deconstruction (Baty, 2009) is followed by deconstructive reflexivity that suggests that the researcher needs to reflect on the implications of the methods used and in particular, the role of the researcher as both observer and writer in the construction of the knowledge that will come about (Bryman & Bell, 2011: 700). Riach (cited in Bryman & Bell, 2011:700-701) suggested participant-centred reflexivity as a balancing force to challenge researcher motives and understanding.

3.6.4. Linear process deconstruction into non-linear capability clusters

If innovation process models are viewed as work sequences that could be rearranged to accommodate changing requirements and insights (Denti & Helmin, 2012), leader competencies may be conceived as clusters of capabilities that serve as a basis for the identification of specific technology innovation leader behaviours deemed to be required for successful technology innovation. The process perspectives in Table 3.4 confirm that the innovation process is complex and multi-faceted and it may even be misleading to refer to a single process (Buijs, 2007).

A recent version of the bio-economy strategy for South Africa (DST, 2014) admitted that the original strategy supported a linear model of science, technology and innovation, and acknowledged the reality of a "non-linear innovation pipeline". Mature bio-economy systems have more complex models that include "industry pull", where applied research "...is guided by industry's needs" where an enabling environment is created to stimulate innovation and allow all stakeholders to interact and extract value through models that can co-exist and complement each other (SA Bio-economy strategy, 2014:1).

By adopting a deconstruction approach as argued above, the innovation process models presented may be broken down into component pieces to allow for re-sorting, rearranging and otherwise moving activities without fundamentally changing the particular leader competencies.

Swart (2013) stated that the innovation process consists of four distinct phases, namely: (i) idea generation; (ii) idea screening; (iii) feasibility; and (iv) commercialisation. Innovative outcomes for a team will only result if team members successfully progress through each of these four phases. The innovation process phases of Swart (2013) are used in Table 3.5 as headings to indicate that activities making up these phases can be found in other process models presented. None of these process models specifically demarcate technology innovation or provide a process that provides clarity on the technology innovation leadership competencies required for successful technology innovation.

Table 3.5: A deconstruction of innovation process models presented

Model	Idea generation	Screening	Feasibility	Commercialisation
Generic	Yes	Yes	Yes	Yes
Push	Yes	Yes	Yes	Yes
Pull	Yes	Yes	Yes	Yes
Coupling	Yes	Yes	Yes	Yes
Integrated	Yes	Yes	Yes	Yes
Open	Yes	Yes	Yes	Yes
Fugle	Yes	Yes	Yes	Yes
Network	Yes	Yes	Yes	Yes
Stage-gate	Yes	Yes	Yes	Yes
Presencing	Yes	Yes	Yes	Yes

Legend: *Yes* indicates assumed interface if commercialisation is replaced by implementation as per the original authors, McAdam and McClelland (2002:87).

Source: Adapted from McAdam and Clelland, 2002: 87.

Table 3.5 suggests that all four of the distinct innovation process phases identified by Swart (2013) may be accommodated in each of the innovation process models reviewed. While Table 3.5 shows idea generation as the first phase of the innovation process (Swart, 2013), idea generation may take place in all the other listed process models, but not necessarily as the first phase in each process model.

De Jong and Den Hartog (2007:42) claimed that:

> *…much of the behavioural research on individual innovative behaviour has focused on creativity, for example, on how leaders can stimulate idea generation. However, when and how creative ideas are implemented, a crucial part of the innovation process, is under-researched.*

Idea generation may occur at different points across the entire innovation process. Traditional practices and assumptions relating to innovation processes were also challenged by Elkins and Keller (2003:588) who claimed that while technology has been " advancing and changing at dizzying rates ... the process by which technological innovation via R&D occurs has been fairly stable over the years" and that innovation teams "...import scientific and technological information, transform this into technological innovations..." and then export these technologies to others to reach the market.

The four phases used by Swart (2013) were adopted from McAdam and McClelland (2002:87) who also stated that "innovation is assumed to be a process with distinct stages stretching from 'idea generation' to 'implementation', which suggests a process that may or may not include commercialisation and which is an important distinction for this study since not all technology innovation would be commercialised.

Recent literature appears to be more critical of conventional innovation process models and their over-simplification of reality. Tidd and Bessant (2013:301) claimed that "The ways knowledge actually flows around an innovation project are complex and interactive, woven together in a kind of 'social spaghetti' where different people talk to each other in different ways, more or less frequently, and about different things" to make innovation happen.

A similar view was expressed by Bausch, Adermann, Andrack, Dengl, Handwerk, Müller, Seifert, Steinke, Sturm, Korb & Meixensberger (2013:1437) based on observations in the spinal surgery field where they had developed a combined design thinking method and cognitive task analysis approach based on user-centred design, instead of the traditional development processes based on focus groups, marketing data or requirements specifications.

Unlike the assembly activities on a manufacturing production line, technology innovation is complex and multi-faceted which places much more emphasis on skills in research, creative thinking, communication and cooperation in interdisciplinary teams (Oskam, 2009). Based on observations in a knowledge-intensive innovation environment, Oskam (2009) found insufficient interaction between development of new knowledge and its exploitation for innovation as just one of several problem areas that is preventing collective innovation capacity to be effectively utilised.

Guest (1991) proposed, and Oskam (2009) expanded the notion of the 'T-shaped professional' or 'hybrid manager'. Like the shape of a 'T', the vertical component refers to domain-specific technical skills, while the horizontal component indicates the need for professionals in different disciplines or functional domains, to acquire sufficient knowledge and understanding beyond their own area of speciality to be able to link with other areas of speciality. The 'T'-shape analogy that has been adopted by a technical innovation team in an Innovation Lab programme may be appropriate for the technology innovation leader being studied in this study and this theme is further explored.

Table 3.5 indicates that the process models presented could be deconstructed as broadly-defined interim capability clusters that "...co-exist and complement each other" (SA Bio-economy strategy, 2014:11). Each of these clusters represents collections of activities that may contribute to technology innovation, but does not necessarily follow in a prescribed sequence and could even be configured to suit particular contexts.

In addition to their important framing comment above that they had assumed a four-stage innovation process for the purposes of their study, McAdam and McClelland (2002:91) also presented the following perspectives that challenge the relevance of using the same four-stage model to identify technology innovation leader competencies deemed to be required for successful technology innovation:

- At companies that are successful, their innovators have a market orientation, a source of ideas, a receptive organisation, and a means to process new ideas.
- A survey of marketing and R&D managers revealed that fewer but more fruitful ideas originated in the R&D department.
- Large companies can match the wealth creating flair of smaller Silicon Valley companies if the creativity potential of staff down the organisational hierarchy can be released.
- Knowledge creation supports idea generation and these events occur prior to the phase of knowledge embodiment in organisational groups, where filtering rules are applied.
- Idea generation based on an expansive view of knowledge creation concerns the grouping and integration of ideas from many sources of accepted knowledge, prior to the screening of ideas.
- For the cycle of differentiation and integration of ideas, there is a need for continuous brainstorming to generate ideas that may have immediate or deferred application.
- Idea generation teams must share goals consistent with an appreciation of the organisation's strategic intent.

In the above discussion, innovation requires a process "...and only if we can manage the whole process is innovation likely to be successful" (Tidd & Bessant, 2013: 21). To manage the whole process includes growing new insights and inventions "into practical use" (Tidd & Bessant, 2013:18) which implies that "to manage" has to be included in any innovation process to be used for identifying leader competencies.

'Symbiosis theory' suggests that "...living things are connected with and dependent on each other to the advantage of both" (Oxford Dictionary, 2009:942), or the fundamental responsibility of an organisation to stay connected with the community by understanding its major issues and problems and suggesting means to resolve them (Symbiosis International University, 2011).

It may be argued therefore, that managing the whole innovation process is likely to include the retention of one or more symbiotic relationships. The retention of a symbiotic relationship with the stakeholder community has not been specifically identified in preceding discussions or process models and is included here as an interim capability set required acros across all phases of the innovation process.

The preceding discussion suggests that technology innovation leaders may not necessarily follow an established pre-defined sequenced technology innovation process model, but may have to be competent to lead technology innovation through mastery of several clusters of capabilities that "...co-exist and complement each other" (SA Bio-economy strategy, 2014:11) in dynamic technology innovation process settings, where steps may not require a pre-determined sequence.

Innovation is defined in this thesis as "a process of turning ideas into reality and capturing value from them – and only if we "can manage the whole process, is innovation likely to be successful" (Tidd & Bessant, 2013:21). Innovation thus implies that the process followed in technology innovation requires clarity on the process and underlying competencies required for doing innovation successfully. Tidd and Bessant (2013: 77) observed that the understanding of the nature of the innovation process had been evolving and that innovation as a multi-actor process had become more do-able through IT-based networking which allows for increasingly complex interactive models that may appear complex, yet still apply the same basic process framework.

Table 3.6 shows the original four-stage innovation process phases of Swart (2013) as well as interim capability clusters derived from Swart (2013) and other sources listed that collectively appear to represent a holistic innovation process that accommodates the innovation process requirements identified in the preceding discussion. These seven interim capability clusters were later reduced to six as justified in sections to follow.

Considering the preceding discussion, and the deconstruction results conveyed in Table 3.5, this study adopted an interim clustering of capabilities to include the four stages of Swart (2013) and added the above perspectives of McAdam and McClelland (2002) to provide an expanded holistic innovation process, presented in Table 3.6, that can be used to inform the identification of leader competencies where work sequences could be complex (Oskan,2009) and multi-faceted (Buijs, 2007) and rearranged to accommodate changing requirements and insights (Denti & Helmin, 2012).

Table 3.6: Expansion of the four-stage innovation process into seven interim capability clusters

Interim capability clusters	Acknowledged in Swart (2013)	Acknowledged in other sources
Observation of new knowledge		Research (Oskam, 2009) R&D (McAdam & McClelland, 2002) Prior to organisational knowledge embodiment (McAdam & McClelland, 2002)
Evaluation of ignore/play options	Screening (Swart, 2013)	Link knowledge development and exploitation (Oskam, 2009) Market orientation (McAdam & McClelland, 2002) Strategic intent (McAdam & McClelland, 2002)
Able to obtain support of people	Feasibility (Swart, 2013)	Receptive organisation (McAdam & McClelland, 2002)
Able to ideate new possibilities	Idea generation (Swart, 2013)	Different domain skills (Oskam, 2009) Source of ideas (McAdam & McClelland, 2002) Release creative potential (McAdam & McClelland, 2002) Idea generation may occur at different points (De Jong & Den Hartog, 2007)
Creating technology solutions		Complex multi-faceted (Oskam, 2009) Means to process ideas (McAdam & McClelland, 2002)
Implementing technology solutions	Commercialisation (Swart, 2013)	Implementation (DeJong & Den Hartog, 2007)
Integration activities across innovation process.		Acknowledge actual knowledge flows (Tidd & Bessant, 2013) Combined design thinking (Bausch *et al.*, 2014) Processes co-exist and complement each other (SA Bio-economy strategy, 2014) Continuous brainstorming (McAdam & McClelland, 2002)

3.6.5. Section synthesis

The preceding section considered innovation processes mentioned in innovation literature with the aim of answering the sub-research question of “which process to select from the range”?” No particular process emerged as being appropriate for answering the question because their sequences differed which would prevent their inter-changeable features, or pre-suppose a set of leader competencies based on the choice of process. The decomposition of processes in Section 3.6.3, however, allowed for more flexible processes and for leader competencies to be applied in different sequences as the context changes. Sub-research question SRQ 1.3 in Table 3.1 was thus answered.

Having observed that context-specific sequences of capability clusters would be applicable to the innovation processes reviewed, another observation may be linked to the dynamic turbulent science and technology landscape envisioned for the future in which technology innovation leaders will have to operate (Brynjolfsson & McAfee, 2014; Schwab, 2016), as implied in Figure 3.21.

The shifts from the industrial to creative era shown in Figure 3.21, provides for and indeed calls for a more flexible process approach that would move away from a predetermined process and then fitting people to it (Yukl, 1994) towards a creative approach that would allow the liberation of people to focus on bigger, better, faster and new. With this shift being acknowledged as a likely determinant in addressing process/people matching, the other sub-question in the provisional conceptual model, about the leader competencies required for successful technology innovation, will be reviewed next.

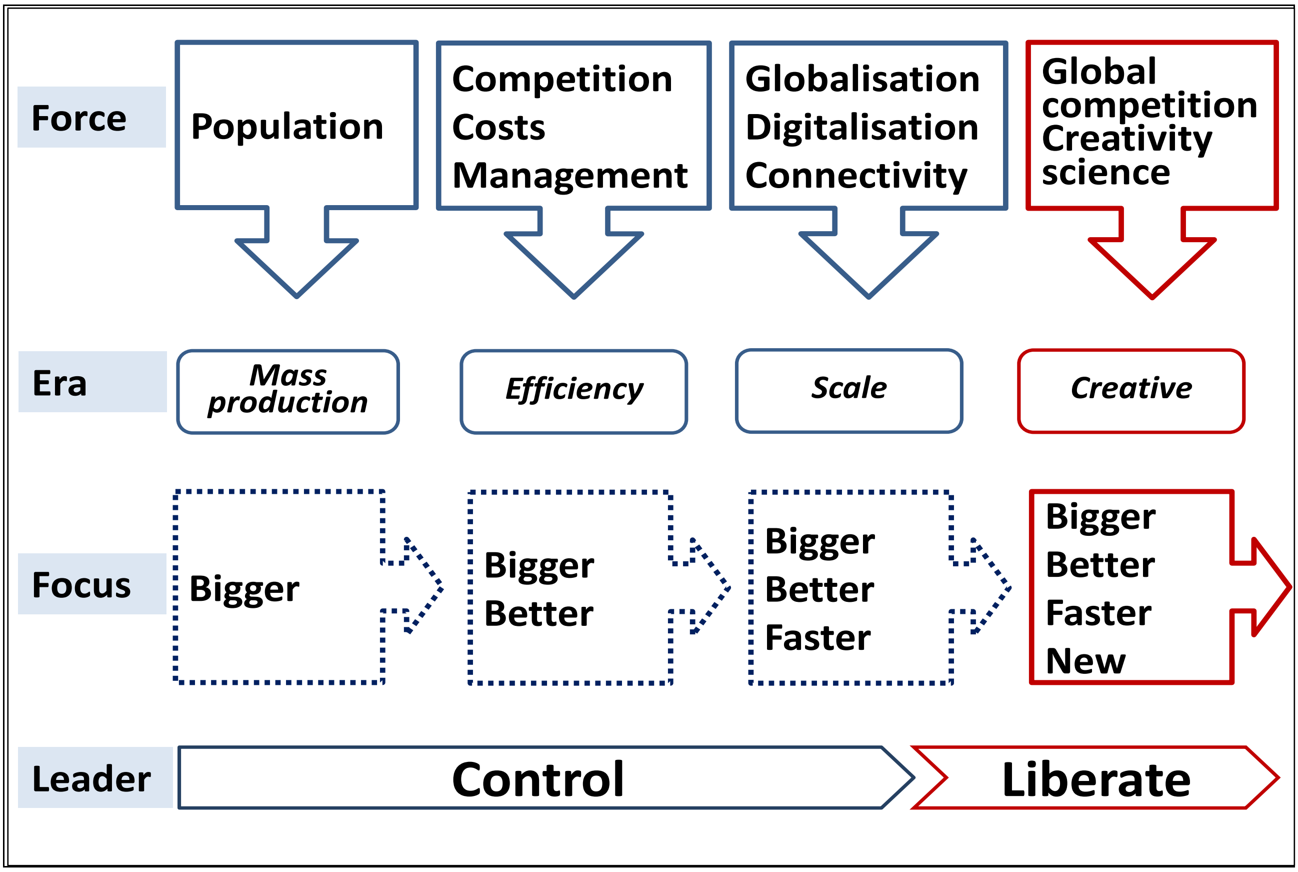


Figure 3.21: Shifts from industrial era to a creative era

Source: Adapted from Kistetter, Eager, Kolk and Roos, 2013.

3.7. LEADERSHIP THEORIES IN INNOVATION LITERATURE

The aim of this section is to identify and review literature related to the competencies of technology innovation leaders to answer research sub-questions RSQ 1. 2 The provisional conceptual model for this study provides a structure for a review of literature on technology innovation leader competencies, based on the capabilities that make up the work to be done in "...delivery of desired results" (Bartram, 2006:2):

- Capability to connect with evolving science and technology;
- Capability to align stakeholder s support;
- Capability to liberate mindsets;
- Capability to facilitate value creation;
- Capability to facilitate value realisation; and
- Capability to integrate through leadership.

As mentioned before, the study of leadership is not new and the knowledge base is extensive. Studies combining leadershipand innovation are relatively new (Hill *et al.,* 2014) and finding scholarly reviewed publications about the leader competencies of leaders of innovation across the innovation process, and more specifically on technology innovation, was found to be challenging (Malhotra, 2015). There appears to be no shortage, however, of opinions being made available in the popular press and social media. This section thus focussed more on developing a broad understanding of the field rather than attempting to establish a definitive collection of valid and reliable research results, and selectively considered views of technology innovation leadersof technology innovation and observers reporting on their competencies. The sharing of successful practices by practicing experts can serve cognitive functions commonly attributed to boundaries and rules, and when this happens, knowledge develops differently from the way it does when governed by rules and such paradigms become essential for continued research (Kuhn, 2012:22). Bryman and Bell (2011:10) emphasised that in many instances theory is latent or implicit in the literature of existing available theories relating to a research topic that can be used to establish a nested model based on their coherence, necessity and sufficiency (Malhotra, 2015). Such derived perspectives act as the equivalent of a theory and enables the researcher to seek and resolve inconsistencies based on research questions that arise from an interrogation of the literature that allows for data collection and analysis that aim to resolve the research problem (Bryman and Bell, 2011:10). This section thus considered theoretical perspectives that relate to the process of turning ideas into reality and capturing value from them (Tidd & Bessant, 2013). We need ways to "navigate through partial lenses onto situations that are held as an absolute truth" to find ways of dealing with "multiple truths" before we will understand co-created viable solutions (Pampallis, 2016:1).

This section starts with an orientation around management and leadership, then presents some changes observed, a review of leadership theories and concepts referred to in innovation literature and then leader competencies related to the respective capabilities.

3.7.1. Orientation

Management and leadership are terms that some sources use interchangeably while others observe differences that may influence the review process, and a stance on this needs to be declared.

Management activities "can best be analysed in terms of four essential groups of activities, namely planning, organising, motivating and controlling" (Cole, 2004:3). Based on a review of management theory, Cole (2004) concluded that managers apply a universal set of goal-directed rational principles in order to achieve organisational efficiency. Cole (2004) claimed efficiency as the primary driver of competitiveness, and innovation is not mentioned. According to Cole (2004), the task of management takes place in an organisational context and presents a thought pattern that acknowledges sameness, efficiency, effectiveness and predictability as basis for increased competitiveness. None of Cole's observations on management acknowledge innovation or the contribution of individual workers in innovation towards competitiveness of the organisation. Conventional management practices are regarded as inadequate for innovation leaders that should address innovation challenges (Sen, 2011; Sutherland, 2013).

As defined before, leadership "is about motivating people and about inspiring them to go the extra mile – something that is often required in innovative projects" while management is about directing people, efficiency, structuring and organising (Von Stamm, 2009:465). VonStamm also differentiated between leaders for innovation and leaders of innovation, the latter being the focus of this study (Von Stamm, 2013). While Von Stamm acknowledged complementary perspectives, some researchers have promoted the argument that leaders have vision and think creatively, "while managers are merely drones and just focus on doing things better", thereby devaluating management (Tidd & Bessant, 2011:111) or claiming that "management is about things and processes, while leadership is about people, showing the way and change" (Gill, 2011:2). "Creativity is present both when doing things differently and doing things better", suggesting that leadership and management may be two constructs on a continuum, rather than two opposing characteristics" and that a definitive resolution on the differences between the two would be unnecessary and unproductive (Tidd & Bessant, 2011:111). This study thus explored leadership theory of possible relevance to the identification of technology innovation leader competencies, and accommodated relevant management competencies presented in innovation literature and theories.

The shifts from the industrial era to the creative era presented in Figure 3.21, provide a basis from which to present published perspectives of relevance to the sub-research question "what leader competencies are deemed to be required for technology innovation success?” From what will be presented, it wil become clear that this question cannot be fully answered from available literature for several reasons.

Firstly, there are scoping issues such as authors not being specific about inclusion or exclusion of technology innovation. Secondly, the unit of measurement is seldom indicated with observations at organisation levels and observations made at technology innovation leader level seldom being clear, which leaves interpretations to the reader. Thirdly, the views presented by Kistetter, Eager, Kolk and Roos (2013) were not available before 2013 for prior contributors to consider, suggesting that sources may not have indicated a position on this observed shift.

3.7.2. Contributions towards evolving understanding of innovation leader competencies

Before linking previously identified leader competencies with capability clusters, some understanding is required of the evolving nature of how observations are made and what is being observed. The availability of theoretical frameworks for research into innovation leadership competencies remain scarce, fragmented and incomplete (Fagerberg, 2003; Hill *et al.,* 2014; Wittenberg, 2011) but various authors have contributed to an evolving understanding of innovation leader competencies over time, as illustrated in Figure 3.22.

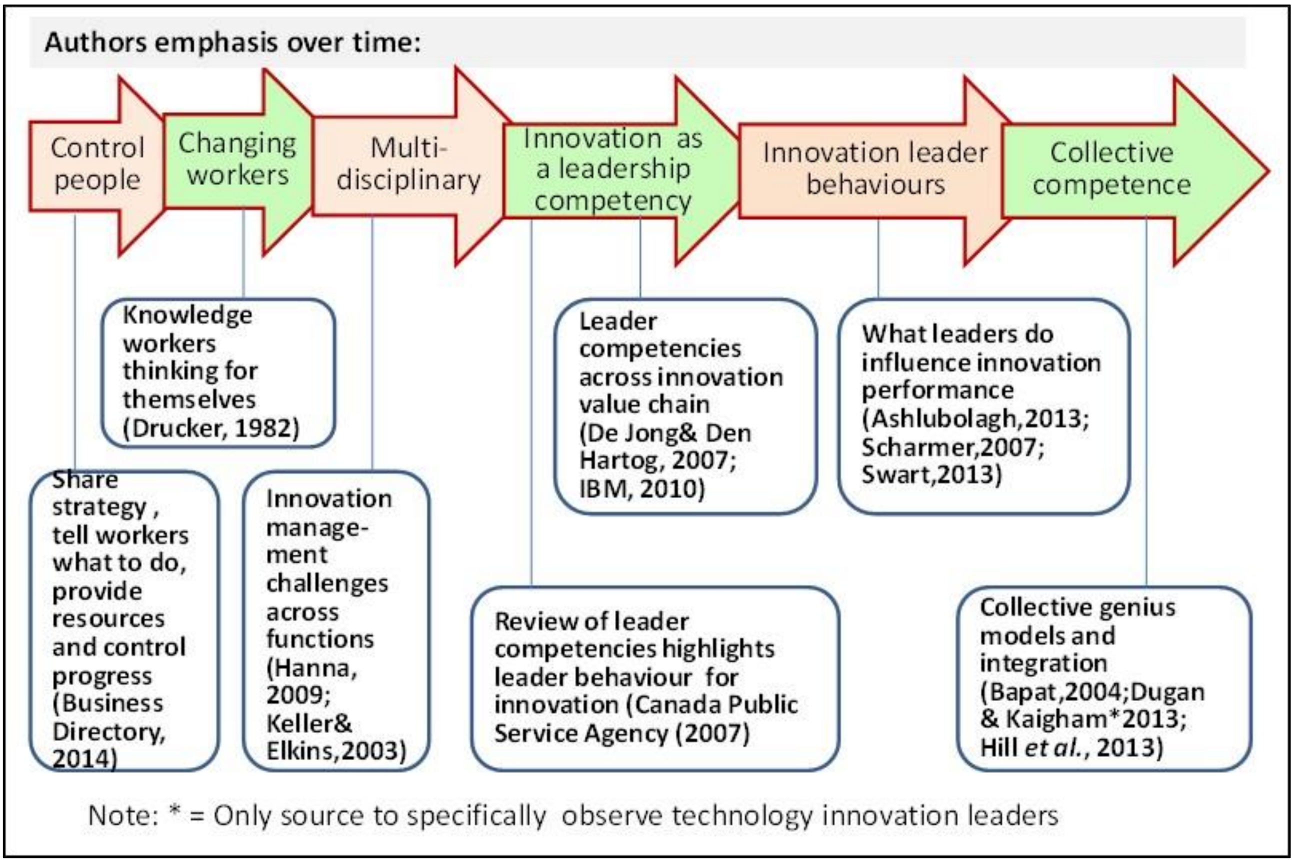


Figure 3.22: Shifts in innovation leader competencies

The nature of the knowledge gap was also articulated differently by different authors as summarised in Figure 3.23, resulting in different leader competency requirements being emphasised that may may reveal possible tensions such as conflicting views.

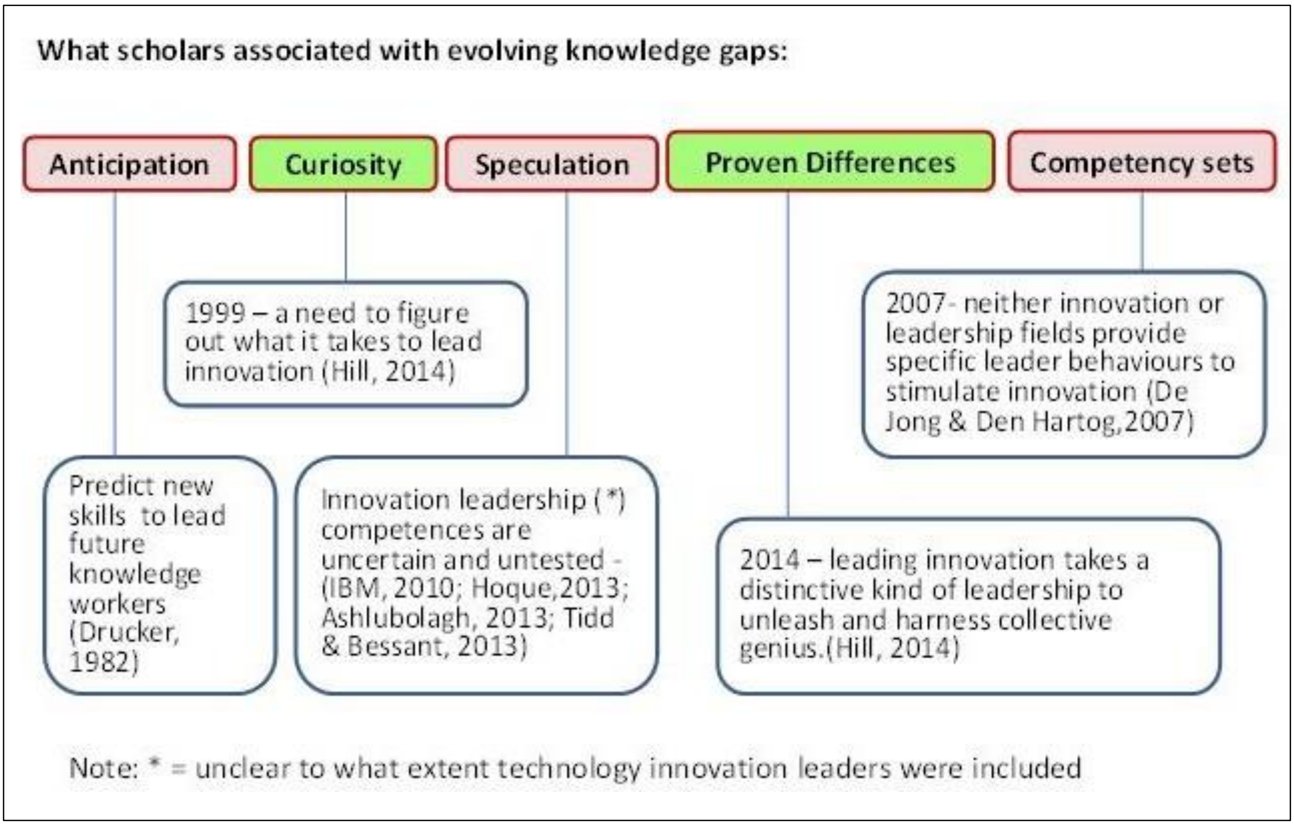


Figure 3.23: Scholars associated with innovation leadership knowledge gaps

As an early scholar and contributor to the current understanding of innovation, Peter Drucker (1982:46), believed:

> *[that] ...managers always have to be stewards of what already exists; they have to be administrators. They also have to create what is to be; they have to be entrepreneurs, risk-takers and innovators.*

Years later, Drucker (1982:233) emphasised the need for leading people to create, but warned against the fallacy of human creativity, namely to "...free people from restraint and they will come up with far better, far more advanced, far more productive answers than the experts". Drucker (1982:236) continued:

> *Creativity, if we mean by that undirected, unstructured, untutored, and uncontrolled guessing, it is not likely to produce results. But a system that does not tap and put to use the knowledge, experience, resources, and imagination of people who have to live with the system and make it work is just as unlikely to be effective.*

It is clear that the innovation leader competencies discourse has taken on different guises over time, which further complicates the identification of leader competencies as envisaged in this study.

The final observation regarding the evolving knowledge gap concerns the extents to which technical competencies are included or excluded, because this determines the extent to which technical or functional competencies are included in the capability clusters.

Technology innovation requires more than technical competencies. According to Elkins and Keller (2003:588), technology has been "...advancing and changing at dizzying rates in the past decades with no let-up in sight", but the process by which technological innovation via R&D occurs has been fairly stable over the years". Elkins and Keller (2003) also noted that leading creative and innovative individuals require leaders to possess other skills in addition to technical expertise. While change can be noticed in how more people can collaborate and compete in real time, there seems to be little change in how we think about and educate for leadership (Von Stamm, 2012). Leadership can take place at any level in the organisation and is about inspiring people and motivating them to go the extra mile as is often required in innovation (Von Stamm, 2009:465; Von Stamm, 2013).

Schilling (2010:272) also emphasised leader competencies beyond technical competencies and used the term "multilingual skills" to indicate that the team leader "must be able to talk the language of marketing, engineering, and manufacturing...and be able to exert influence upon the engineering, manufacturing, and marketing functions".

Hogan and Coote (2014) praised the value of empirical research to understand behaviours resulting in innovation in tangible product and manufacturing environments. Hogan and Cloete (2014:1611) also appealed for a broader conceptualisation of innovation to include behaviours supporting the provision of innovation solutions to client problems that involves tangible product elements and perishable, intangible services elements. The broader conceptualisation proposed by Hogan and Cloete (2014:1611) includes innovative behaviours directed towards the development of client-focused, marketing-focused and technology focused innovation activities.

The identification of leader competencies from literature will thus adopt a broader inclusive approach in line with the conceptual model.

3.7.3. Specific contributors to identification of innovation leader competencies

Contributors to the evolving understanding of technology innovation leader competencies are presented as two groups. The first group are those who are cited in the innovation literature for innovation-related contributions whose work may not have been integrated into innovation leader concepts yet, but cannot be ignored because of their assumed significance in the identification of technology innovation leader competencies. The second group contributed more-specific leadership theories or approaches for consideration in the identification of technology innovation leader competencies, as summarised in Table 3.7 and discussed thereafter.

In the first group, Prahalad and Krishnan (2008) provided their views on the future of innovation in organisations, suggesting that innovation will be driven by seamless integration of strategy, business processes, technology,co-creation of value through global networks of resources to create unique experiences for each customer, requiring transformation at all levels, including business processes, systems, supply chain management, social and technological infrastructure for ongoing differentiation through innovation. While these views of Prahalad and Krishnan (2008) are aligned with more recent observations by others (Schwab, 2016), the implications for technology innovation leader competencies were not clear yet and were further explored in Chapter 5.

Servant leadership may relate to the behaviours of innovation that are associated with listening to their people and making them believe that they are capable of innovating, and is included here to reinforce observations of other authors in this section who claimed that power-seeking leaders would not achieve the same levels of ownership as leaders who come across as being confident, yet humble and to some extent vulnerable (Greenleaf, 1977). Greenleaf (1977:20) developed his servant leadership theory, which suggests that in addition to leading, the leader should also be "...searching, listening, expecting that a better wheel for these times is in the making", rather than reinventing the wheel. Greenleaf explored traditional constructs of power and authority to conclude that:

> *...people are beginning to learn, however haltingly, to relate to one another in less coercive and more creatively supporting ways. A new moral principle is emerging which holds that the only authority deserving one's allegiance is that which is freely and knowingly granted to the leader in response to, and in proportion to, the clearly servant statute of the leader* (Greenleaf, 1977:20).

Complexity leadership theory developed by Uhl-Bien, Marion and McKelvey (2007) poses an alternative to dominant top-down management models that are effective in stable, productive-orientated economies, but not suited for the modern, less stable, knowledge-intensive economy. Complexity leadership theory views leadership as a complex interactive dynamic that promotes the emergence of adaptive outcomes (learning, innovation, adaptability).

> *It is a leadership framework that enables the learning, creative, and adaptive capacity of Complex Adaptive Systems (CAS) within the context of knowledge-producing organisations and describes three interacting leadership roles: administrative, adaptive, and enabling... leadership is too complex to be attributed to the acts of only an individual or individuals, and is rather a complex relationship of many interacting forces* (Uhl-Bien et al., 2007:2,9).

Theresa Amabile (1996; 1998) appears to be widely recognised in innovation literature for her work on creativity, initially individual creativity and later organisational creativity. While the link to the identification of technology innovation leader competencies may not be clearly articulated, it is argued here that innovation leaders might bring about greater creativity in support of innovation if they are aware of her work, because they can create opportunities and access resources for bringing about creativity. The underpinning logic here is that leaders create creativity-fostering environments that may be conducive to innovation or that stifle innovation. Three factors work together to bring about increased levels of innovation, namely: (i) expertise and knowledge; (ii) creative thinking skills; and (iii) intrinsic task motivation.

i) Expertise and knowledge

Almonaitiene (2013:82) proposed team design for creativity. Leaders must create mutually-supportive groups with a diversity of perspectives and backgrounds, with member willingness to help their teammates through trying times. Every member must recognise the unique knowledge and perspective that other members bring to the table. Fagerberg (2003) claimed that innovation leaders should be able to allow for a variety of perspectives in contrast to the homogeneous unitary leader style that management literature favours.

A leader should capture and diffuse learning from projects (Tidd & Bessant, 2011:16). The OECD (2000:5) added mobility of scientists between science and industry. According to Barczak (2015:2), an innovation team should have diversity in two dimensions, namely: (i) tenure or multiplicity of members' length of time working in the organisation; and (ii) functional diversity which is the "...assortment of functional disciplines represented" that allows teams to be more creative and solve problems, but such teams are less effective at social integration and cohesion because they lack capabilities for teamwork. Denti and Hemlin (2012) support the need for diversity, yet warned that when diversity is too heterogeneous, tensions may arise, and when there is too little, the leaders may have to apply more directive leadership to promote reflection.

ii) Creative thinking skills

Creative thinking skills enhance innovation. Almonaitiene (2013) added team diversity to include diverse thinking approaches. Hoque (2013) emphasised the leader's role in changing established routines to bring about cross-collaboration. Gryskiewicz and Taylor (2003) promoted understanding of alternative approaches or creative pathways to problem-solving as well as awareness of the requirements for success and avoiding creativity-killer phrases. Conway and Steward (2009:279) believe that innovation routines are "learnt" through experience, are highly tacit yet become stored in the "memory" of the organisation within formal structures, procedures and processes, as well as informal structures and conventions, such that it can be evoked, given the appropriate stimuli.

Amabile (1998:77) argued that leaders should view creativity as a function of three components within individuals, namely (i) expertise or intellectual space used to explore and solve problems,

(ii) creative thinking in how people approach problems and solutions and (iii) motivation. Both Almonaitiene (2013) and Amabile (1998:80) claimed that leaders can bring about more creativity in people through their behaviours. Almonaitiene (2013) added that the leader could broaden expertise and intrinsic motivation through seminars/conferences, training in problem-solving and lateral thinking and changes in the work environment.

iii) Intrinsic task motivation

Motivation determines what people will do and is driven more by intrinsic rather than extrinsic factors (doing it for rewards). Amabile (1998:79) strongly emphasised the critical importance of intrinsic motivation for creativity, where people are driven by internal passion and interest in the work itself. This study assumes that this is also valid in the technology innovation field since no evidence could be found to indicate the contrary. This implies that people will be most creative when they feel motivated primarily by the interest, satisfaction, and challenge of the work itself- and not by external pressures.

Innovation requires creativity which is often regarded as the engine of the 21st century global economy. The competence of leaders to facilitate desired levels of creativity is thus seen as an important consideration for possible inclusion as a competency in this study. Based on literature analysis and empirical qualitative research, Almonaitiene (2013:54) provided a strong case to include creativity in two leadership competency areas.

Firstly, creativity is seen as a leadership competency, which implies the ability of leaders to be creative themselves. This finding is supported by the research of the International Business Machines Corporation (IBM) (MacDonald, 2010) where creativity was identified as one of the most desired competencies of future leaders.

Secondly, creativity of those influenced by the leader is seen as important for innovation and the implication is that leaders need to be competent in bringing about creativity in their followers. The researcher presents empirical evidence with respect to such factors of creativity and leadership as emotional involvement and the work-way of life connection. Creativity as competency features in seminal papers by Amabile and co-authors in the late 1990s and early 2000s. Creativity is seen as providing novel or useful ideas which are critical for innovation, which is about the successful implementation of ideas.

Amabile (1998:77) said to leaders: "...if you want to spark innovation, rethink how you motivate, reward and assign work to people". This suggests that leaders' behaviours affect creativity through the three components captured in Figure 3.24.

Anderson *et al.* (2014:1322-1323) suggested that far more could be done to elucidate the effects of leadership style and behaviours on creativity and innovation at different stages in the innovation cycle and particularly how leaders handle the competing demands and call for more research to determine if it is possible for leaders to modify behaviour dependent upon the stage in the innovation cycle.

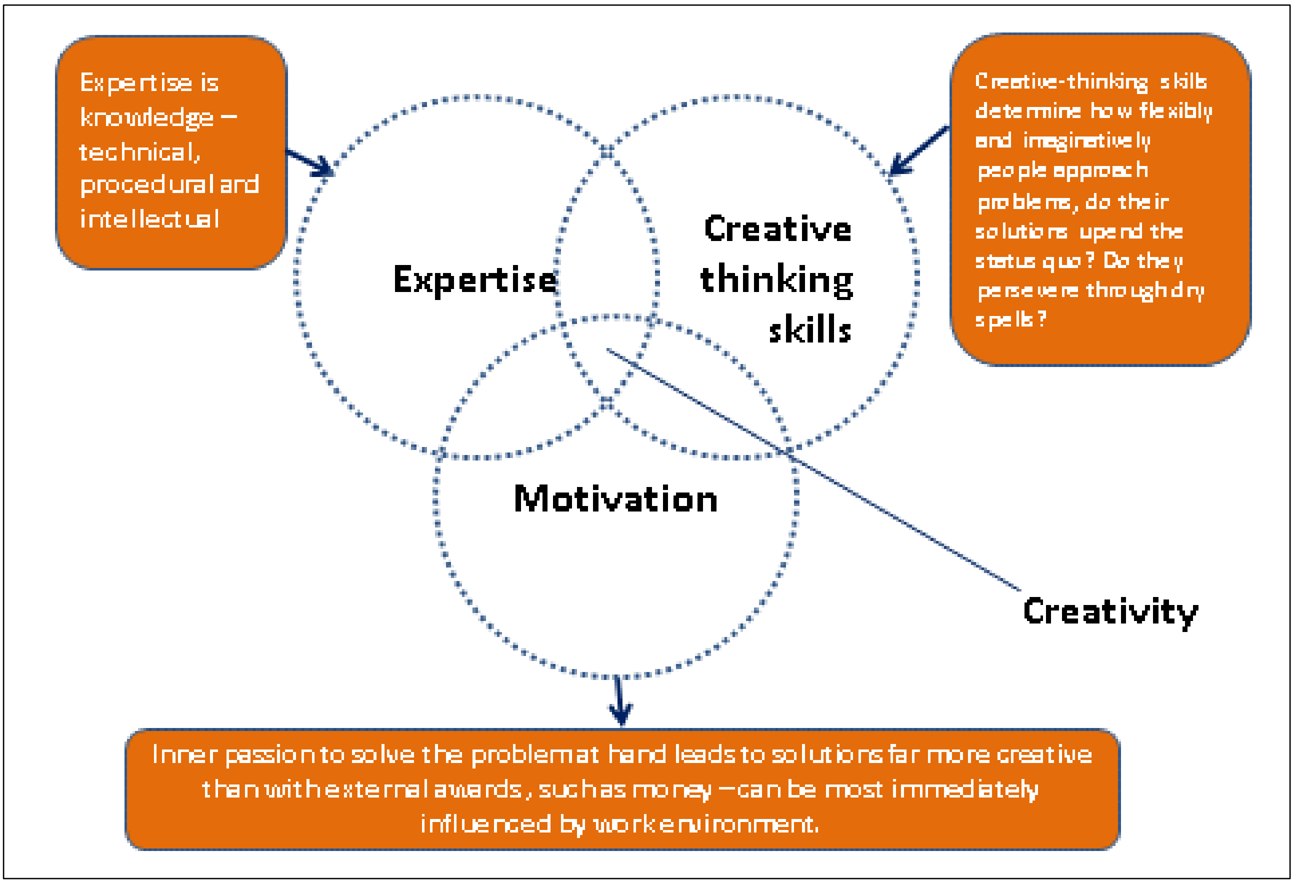


Figure 3.24: Three components of creativity

Source: Adapted from Amabile, 1998:77.

The second group of contributors mentioned at the start of this section are tabled in Table 3.7 and discussed thereafter.

Table 3.7: Summary of leadership theory perspectives to identify competencies

Leadership theory	Implied guidelines to identify technology innovation leader competencies
Transformational leadership	Inspire, energise and intellectually stimulate followers in pursuit of a technology innovation cause or vision (Bass, 1990; Bry, 2015; Elkins & Keller; 2003; Rosing *et al.,* 2011; Swart, 2013; Flatten *et al.,* 2014). Facilitate knowledge absorption to stimulate team innovation (Flatten *et al.,* 2014).
Path-goal theory of leadership	Create goal paths through attraction and participation (House & Mitchell, 1975). Demonstrate behaviours that can be emulated by peer leadership to facilitate collaborative, positive team interaction and close satisfying relationships among team members (House, 1996:341).
Leader-member exchange theory (LMX)	Develop high-quality leader-member relationships with member-based commitment, mutual respect and liking (Graen & UhlBien, 1995; Rosing *et al.,* 2011:964; Elkins & Keller, 2003:587; Anderson *et al.,* 2014:1322; Swart, 2013; Aspen Institute, 2015).
De Jong & Den Hartog: Innovation leader behaviour inventory	Innovation leader behaviour inventory includes leader behaviours that influence both idea generation and idea application listed inTable 3.10 (De Jong and Den Hartog, 2007): Innovative role-modelling (Almonaitiene, 2013; Conway & Steward, 2009; Gliddon, 2006; Hogan & Coote, 2014; Muller, 2013; Rosenfeld & Kolstoe, 2006; Swart, 2013; Ungerer, Herholdt & Le Roux, 2013)
Total innovation management framework	Approach innovation as a long-term competency-based management philosophy for achieving sustainable competitive advantage involving all people at every aspect and organisational level, at all times and across all spaces (Xu *et al.,* 2007:16).
Gliddon: Innovation leaders' competency model	Facilitate forward and backward flows of influences, activities and information between individual and group creativity across innovation process stages (Gliddon, 2006).
Swart: ILQ competencies	Innovation leader competencies in an Innovation Leader Questionnaire (ILQ) (Swart, 2013)
Hill: Collective genius	Build a community with a sense of shared purpose (reason for existence), values (what is agreed as important and rules of engagement) how to interact with each other and think about problems (Hill *et al.,* 2014:191). Build organisational capability to generate ideas through discourse and debate (Hill *et al.,* 2014:191). Build organisational capability for creative agility (the ability to test and experiment through quick pursuit, reflection, and adjustment) (Hill *et al.,* 2014:191). Build organisational capability for creative resolution (the ability to make integrative decisions that combine disparate or even opposing ideals) (Hill *et al.,* 2014:191).
Integrative leadership	Lead by integrating people and technology considerations towards innovation (Youn, Yang and Hong, 2012; Rothaermel & Hess, 2007).
Special forces framework	Military model may offer leader elements for consideration (Dugan & Gabriel, 2013)

Other authors contributed perspectives that could be more specifically related to technology innovation leader competencies and are discussed next.

3.7.3.1. Transformational leadership

Transformational leadership appears to be the most dominant and widely-researched leadership theory associated with innovation in general. Some studies reveal empirical evidence of improved innovation results within organisations because of transformational leadership (Flatten *et al.,* 2014; Rosing *et al.,* 2011; Swart, 2013), while Samad (2012) pointed out that, based on a literature review, research results remain inconclusive.

Transformational leadership implies leaders who inspire, energise and intellectually stimulate their followers (Bass, 1990:19) in pursuit of a shared vision that may include an innovation vision (Bass, 1990:19), and more specifically a technology innovation vision (Elkins & Keller, 2003). Flatten *et al.* (2014) found strong positive relationships between transformational leadership and knowledge absorption and innovation generation in teams.

Bass (1990) contributed to the understanding of innovation leader competencies by consolidating the work of many other scholars to emphasise a shift away from control-based leadership where people have to comply, towards transformational leadership which engages people through their support of a worthy cause or vision, and doing so because of their own free will. Elkins and Keller (2003:587) cautioned against generalising as Bass' (1990) research was mostly not done in innovation environments. Their own research findings, however, suggest that transformational project leaders who communicate an inspirational vision and provide intellectual stimulation are associated with innovation project success (Elkins & Keller, 2003).

More recently more authors made claims that resemble the views of Bass (1990). Based on observations in Silicon Valley, which most innovators would associate with a high and consistent technology innovation track record over decades, Lobel (cited in Bry, 2015) suggested that free choice offered to talented people may be a significant factor in attracting and mobilising innovation energy or uncovering the ingredients to triumph in the innovative eco-system, leveraging the best people. Too much control of talent appears counterproductive, because they prevent the freedom and flow of knowledge that is critical to innovation. In order to achieve innovation levels like Silicon Valley did, leaders should focus on behaviours that may improve motivation, relationships and mobility by building inspirational futures through less direct influence, more awareness and engagement.

Rosing *et al.* (2011) claimed that transformational leader behaviours in innovation should foster both opening or exploration and closing or exploitation dimensions of innovation, as contrasted with transactional leadership in Table 3.8. Their inclusion of transactional leadership in their Ambidexterity theory of leadership is justified by their analysis of prior studies that mostly found a negative correlation with innovation success, except for parts of the innovation process that required structured exploitation in tandem with exploration.

Table 3.8: Opening and closing behaviours used by innovation leaders

	Opening leader behaviours	Closing leader behaviours
Transformational leadership	• Develop a vision that motivates exploratory behaviour • Stimulation of thoughts in very new directions • Communicate the values of openness and tolerance	• Develop a vision that motivates confirmatory behaviour • Stimulation of thoughts for small improvements and enhancement of efficiency • Communicate the values of conscientiousness and rules adherence
Transactional leadership	• Rewarding experimentation • Focus on errors to learn from errors • Set and monitor exploration goals	• Rewarding efficiency • Focus on errors to avoid errors • Set and monitor exploitation goals

While Rosing *et al.* (2011) did not explicitly acknowledge technology innovation leaders, their contribution introduced a new approach to innovation leadership behaviours required across the innovation process, irrespective of the innovation process used. Their approach can bridge some of the concerns expressed in this thesis on the conflicting or contradicting requirements posed by innovation process models on the technology innovation leader competencies required for successful technology innovation and supports the use of deconstruction techniques in Section 3.6 (Baty, 2009).

3.7.3.2. Path-goal

The path-goal theory of leadership focuses on the effects of leaders on a subordinate's motivation, satisfaction and performance (House, 1996). This theory proposes that effective leaders engage in behaviours that complement subordinates' environments and abilities in a manner that compensates for deficiencies and is instrumental to subordinates' satisfaction levels, as well as individual and work unit performance.

The theory specifies classes of leader behaviours that are theoretically acceptable, satisfying, facilitative and motivational for subordinates. According to House (1996:346), Bowers and Seashore found strong evidence that leader behaviours can be shared by members of a work group and that such 'peer leadership' often had a higher correlation with unit performance than leadership exercised by the formal manager of the unit. The highest correlations between manager and peer leadership behaviours were in manager and peer work facilitation, goal emphasis, peer interaction facilitation and peer support, suggesting that the manager sets the example appropriate for peer leader behaviour.

The relevance of the above findings for this study may thus be its strong case for technology innovation leaders to lead by example and secondly, the significance of peer leadership when the leader creates an environment in which peer leadership is nurtured. Of significance to this study is what House (1996:341) calls “Interaction Facilitation”, which is described as leader behaviour that facilitates collaborative and positive interaction consisting of resolving disputes, facilitating communication, giving the minority a chance to be heard, emphasising the importance of collaboration (leader as champion and gatekeeper, Elkins & Keller, 2003) and teamwork, and encouraging close satisfying relationships among its members. These elements are integrated in the emerging theoretical model as expressed in the scoping sections of this study.

Despite its virtues, as identified above, the path-goal theory of leadership does not accommodate some of the dynamics found in technology innovation leadership situations. House (1996:348) acknowledged that his theory still does not accommodate emergent-informal leadership, leadership across multiple levels of management and supervisors in organisations, political behaviours of leaders, strategic leadership and leadership as it relates to change.

3.7.3.3. Leader-member exchange theory

Rosing *et al.* (2011:964) compared results from prior studies and claimed that leader-member exchange (LMX) displayed a moderate to high and consistent relationship with innovation success. According to the leader-member exchange theory of Graen and Uhl-Bien developed in 1995, leaders establish different quality relationships with their subordinates as both parties mutually define the subordinate’s role (cited in Swart, 2013:30). Exchange relationships are formed based on personal compatibility, subordinate competence and dependability.

Leaders establish either high-exchange or low-exchange relationships with their subordinates. High-exchange relationships are based on the leader’s control over outcomes that are considered desirable to subordinates, such as improved innovation, benefits in the form of personal support and approval and support for the follower’s career progression through high visibility assignments. Worker loyalty and hard work appear to be typical outcomes of such high exchange relationships. Elkins and Keller (2003) found that leaders who develop a high-quality leader-member exchange (LMX) relationship with project members are associated with innovation success (Anderson *et al.,* 2014:1322; Elkins & Keller, 2003:587; Kheng & Mahmood, 2013:30). High levels of commitment, trust, mutual respect and liking develop between leaders and their workers and these are seen as essential components in facilitating high levels of innovative behaviour in subordinates (Aspen Institute, 2015).

3.7.3.4. De Jong and Den Hartog: Innovation leader behaviour inventory

De Jong and Den Hartog (2007:57) emphasised that their work should be seen as a contribution to the inventory of leadership “...behaviours that leaders in knowledge-intensive organisations use to stimulate innovation among their employees”. It is not clear from their findings whether their focus on knowledge-intensive service organisations covered the full innovation process, or to what extent technology innovation leaders might have been covered in their work, or to what extent their focus on ‘innovative efforts’ related to implementation or success. They do acknowledge that their findings would have been more valuable if empirical work had been added (De Jong & Den Hartog, 2007). The salient contributions from De Jong and Den Hartog (2003) for consideration in this study are summarised next.

They observed that neither innovation nor leadership studies had produced a detailed overview of specific behaviours that leaders might use to stimulate innovation by individual employees (De Jongh & Den Hartog, 2007: 41).

The purpose of their study was to compile an inventory of leader behaviours, which resonated with the aims of this study where the aim is to identify technology innovation competencies that are deemed to be required for successful technology innovation (De Jong & Den Hartog, 2007). Krause (2004) commented that inventories for apprehending influence-based leadership pertaining to innovation were not available yet and the work of De Jong and Den Hartog (2007) is thus seen as a significant step towards identifying leadership behaviours as contribution to this study.

In identifying leader behaviours, a two-phased innovation process was used. The first phase starts with the production of an idea and continues to the point where an idea is first adopted, meaning a decision is made to proceed with the idea. The second phase ends when an idea is implemented (De Jong & Den Hartog, 2007: 43). Using these two phases as basis, their research concluded with seven leader behaviours as listed in Table 3.10.

Table 3.9: Leader behaviours related to employee idea generation or application

Leader behaviour		Description	Idea generation	Application
1	Innovative role-modelling	Being an example of innovative behaviour, exploring opportunities, generating ideas, championing and putting efforts in development	Yes	Yes
2	Intellectual stimulation	Teasing subordinates directly to come up with ideas and to evaluate current practices	Yes	
3	Stimulating knowledge diffusion	Stimulating open and transparent communication, introducing supportive communication structures like informal work meetings	Yes	
4	Providing vision	Communicating an explicit vision on the role and preferred types of innovation, providing directions for future activities	Yes	Yes
5	Consulting	Checking with people before initiating changes that may affect them, incorporating their ideas and suggestions in decisions	Yes	Yes
6	Delegating	Giving subordinates sufficient autonomy to determine relatively independently how to do a job	Yes	Yes
7	Support for innovation	Acting friendly to innovative employees, being patient and helpful, listening, looking out for someone's interests if problems arise	Yes	Yes
8	Organising feedback	Ensuring feedback on concepts and first trials, providing feedback to employees, asking customers for their opinion		Yes
9	Recognition	Showing appreciation for innovative performances	Yes	Yes
10	Rewards	Providing financial/material rewards for innovative performances		Yes
11	Providing resources	Providing time and money to implement ideas		Yes
12	Monitoring	Ensuring effectiveness and efficiency, checking-up on people, stressing tried and tested routines (negative relationship)	Yes	Yes
13	Task assignment	Providing employees with challenging tasks, making allowance for employees' commitment when assigning tasks	Yes	

Source: De Jong and Den Hartog, 2007.

While the 13 behaviours listed in Table 3.9 were identified as leader behaviours that were associated with idea generation or application, only the seven leader behaviours with two "yes" responses in the respective columns, were found to be applicable to both idea generation and application. These seven behaviours are are listed in Table 3.10 (De Jong & Den Hartog, 2007:49).

Table 3.10: Innovation leader behaviour inventory

Leader behaviour		Description
1	Innovative role-modelling	Being an example of innovative behaviour, exploring opportunities, generating ideas, championing and putting efforts in development, acknowledging interrelatedness of all innovation activities
2	Providing vision	Communicating an explicit vision on the role and preferred types of innovation, providing directions for future activities
3	Consulting	Checking with people before initiating changes that may affect them, incorporating their ideas and suggestions in decisions
4	Delegating	Giving subordinates sufficient autonomy to determine relatively independently how to do a job
5	Support for innovation	Acting friendly to innovative employees, being patient and helpful, listening, looking out for someone's interests if problems arise
6	Recognition	Showing appreciation for innovative performances
7	Monitoring	Ensuring effectiveness and efficiency, checking-up on people, stressing tried and tested routines (negative relationship)

Source: De Jong and Den Hartog, 2007.

Idea generation and application are the two broad leader behaviour descriptors used by De Jong and Den Hartog (2007) to identify leader behaviours linked to either in Table 3.9 and both in Table 3.10, as if they jointly cover the full innovation process, the information provided by De Jong and Den Hartog (2007) was insufficient to verify their assertion. As a consequence, this study cannot accept or reject these behaviours as potential technology innovation leader competencies without further research into their suitability.

While De Jong and Hartog (2007) used Yukl's (1994) empirically-derived taxonomy of management behaviours to identify leadership behaviours that stimulate idea generation and application as components of innovation, their method of determining which behaviours to retain, modify or drop was not conveyed with sufficient clarity to determine the levels of scientific rigour exercised.

For no apparent reasons De Jong and Den Hartog (2007:41) used Yukl's (1994) taxonomy as input for their study aimed at providing "an inventory of of leader behaviours likely to enhance employees' innovative behaviour, including idea generation and application behaviour".

Yukl (1994) produced a taxonomy of leadership behaviours, in which leaders performed planning and organising involving long-term objectives, resource allocation according to priorities and how to use personnel/resources to accomplish a task efficiently. Leadership behaviours included motivating and inspiring by using influencing techniques to generate enthusiasm for work, commitment to task objectives and compliance with requests for cooperation. Effective performance was praised and recognised as tangible rewards were provided for effective performance, significant achievements and demonstrated competence. Team building and conflict management were combined as one of the 14 leader behaviours and the the focus was on cooperation, teamwork and identification with the work unit. Developing and mentoring included career advice and doing things to facilitate a person's skill acquisition, professional development and career achievement. Clarifying roles and objectives included assigning tasks, providing direction in how to do the work, and communicating a clear understanding of job responsibilities, task objectives and deadlines. Monitoring by the leader included checking on the progress and quality of work, evaluating performance of individuals and the unit, analysing trends and forecasting external events.

Innovation did not appear on Yukl's (1994) list of leader behaviours, and neither did design, create, new, renew, compete, value, stakeholder, paradigm or disrupt.

3.7.3.5. Total Innovation Management framework of Xu

Xu *et al.* (2007:16) described their Total Innovation Management (TIM) framework as "all elements innovation" that involves the creation of synergy between technological (product, process and portfolio) and non-technological (market, organisation and institutional) areas through effective use of tools and facilitating mechanisms that encourage and regulate innovation by all employees. They emphasised technological innovation as the key element in facilitating the satisfaction of customer needs. The non-technological innovation areas are viewed as subsidiary elements that may require relative adjustments in the process of meeting client needs. They further related TIM to innovation in all organisational sectors, all employees, all time and space dimensions, suggesting increased scope and complexity of innovation management that require higher levels of innovation competence. While the conceptual thinking demonstrated in the TIM framework acknowledges the holistic and integrated nature of innovation management, the authors did not provide any thoughts on the leadership competencies required of the technological innovation leader. They are cited here, however, because they appear to be the first to equate innovation management to a concept of total innovation management, which appears very similar to what can be observed in the solution of what is known today as Total Quality Management (TQM). This may be interpreted as a confirmation of the prediction by Clayton Christensen, an international thought leader on innovation management, that innovation as the "new science of success" is likely to follow the path experienced by TQM over approximately thirty years (Christensen, 2002:33). From early quality conversations about product quality and later, process quality and then finally, TQM, innovation also started with product innovation, followed by a process innovation. Should this observation be accurate, the future of innovation leadership may soon evolve to an all-embracing status.

Xu *et al.* (2007) claimed that innovation (including technological innovation) should be approached as a long-term competency-based management philosophy for achieving sustainable competitive advantage, involving all people, at every aspect and organisational level, at all times and across all spaces. This could be interpreted as a possible shift in innovation thinking towards a collective innovation leadership dispensation, within which much of what has been emphasised, by the previously discussed authors could be accommodated.

3.7.3.6. Gliddon's innovation leaders' competency model

Using the results of 50 previous competency studies, Gliddon (2006:ix) engaged innovation leadership experts in a three-iteration Delphi methodology to identify 98 competencies in ten categories at three tiers. Based on the research results, Gliddon (2006) claimed that the individualist perspective used was still in its infancy and that future research would be required to bring the individualist perspective to fruition. It seems as if the experts referred to by Gliddon (2006) were educational specialists and no mention was made of their technology expertise. It could therefore be argued that the findings presented by Gliddon (2006) may not apply to other technology innovation leaders.

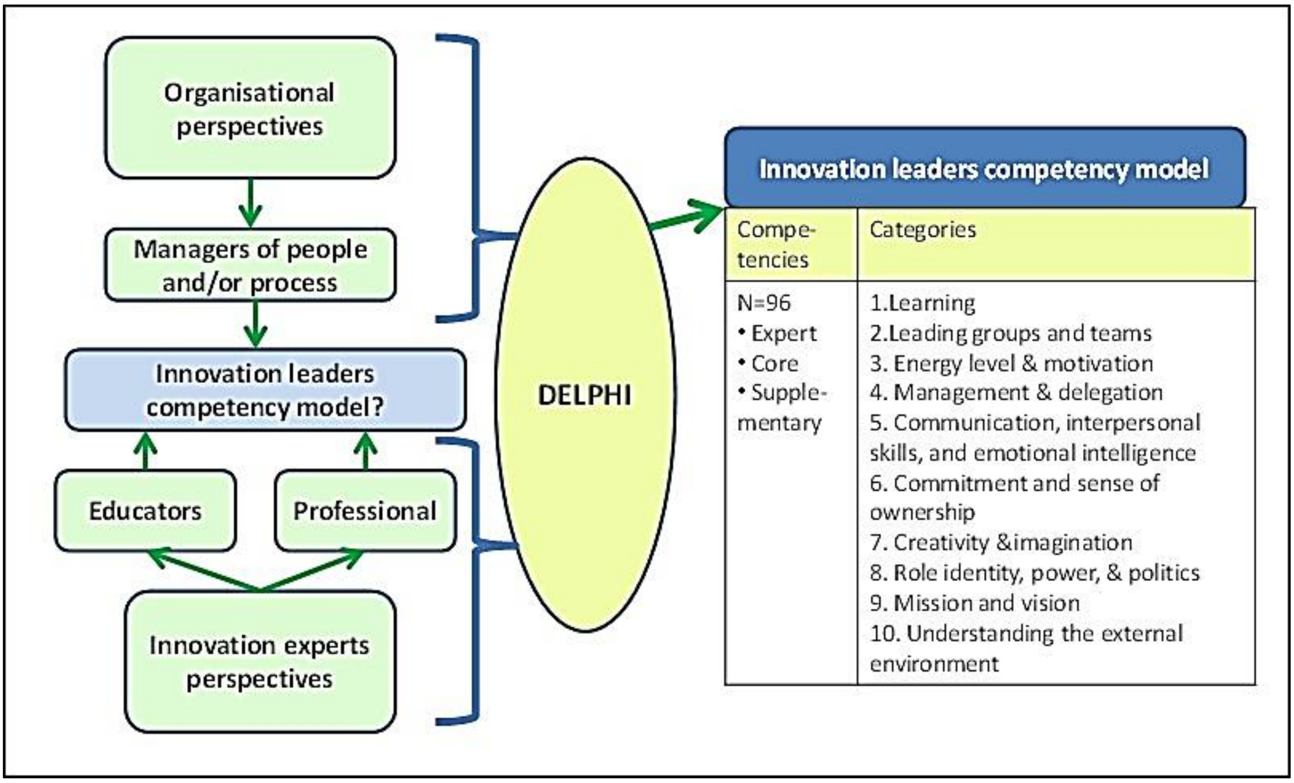


Figure 3.25: Gliddon's innovation leadership competencies

Source: Adapted from Gliddon, 2006.

Gliddon's innovation leadership model in Figure 3.25 is based on a simple three-step innovation process that starts with (i) idea generation, followed by (ii) evaluation and then (iii) implementation. Gliddon (2006) raised some concern about the apparent sequential flow of the three steps when his work clearly states that these three stages of innovation are not independent of one another and that stages in the model should not be viewed in a "lock-step" fashion. Gliddon (2006) held the view that there are both backward and forward influences and activities affecting each of the three stages. Ideas may be generated, discussed, and tested only to feed information back into the system, starting the process from the beginning again. Forward and backward flows between individual creativity and team creativity, forward and backward flows between team creativity and organisational innovation, as well as from organisational innovation to individual creativity is discussed in the Gliddon model.

There are, however, a relatively large number of identified competencies that resonate with competencies identified by other authors and these are integrated for possible verification during the empirical phase of this study.

3.7.3.7. Swart's innovation leadership questionnaire competences

Swart (2013) reinforced the concept of innovation leadership when a set of 68 validated innovation leadership behaviours were identified and incorporated into a theoretical framework as shown in Figure 3.26. These are further discussed in the next chapter. The innovation leadership questionnaire (ILQ) developed by Swart (2013) seems to contain a more comprehensive set of innovation leadership competencies than other sources found in literature. The 68 identified leader behaviours were scientifically derived and have complied with stringent research requirements and it is very recent, which is why much of the literature was considered as input to this study. The complete set of ILQ competencies published by Swart (2013) is contained as Appendix F to this report.

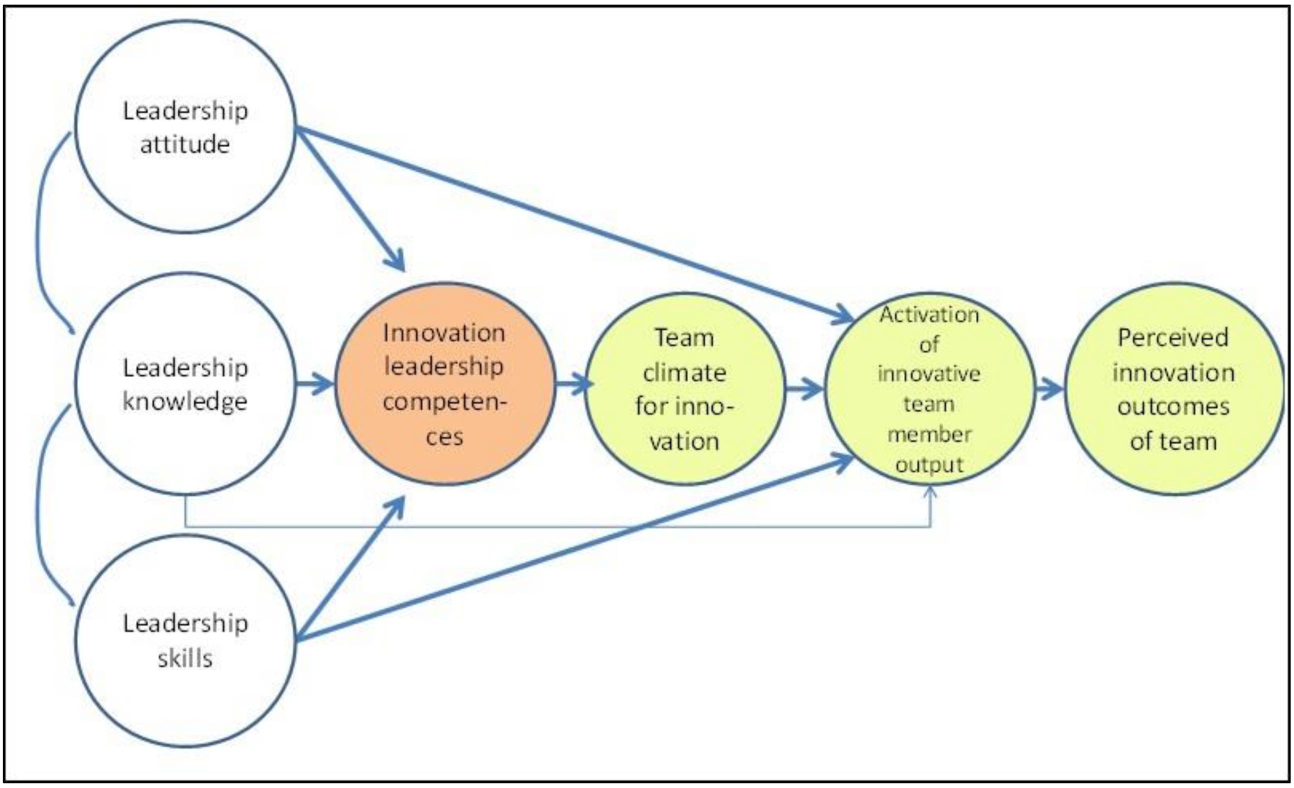


Figure 3.26: Theoretical perspectives of Swart

Source: Swart, 2013.

Technology innovation leader competences, which are the focus area of the study, did not explicitly feature in the design and development of the ILQ. Because of the scientific process followed in the ILQ development, however, the final list of ILQ behaviours serves as a primary input into the identification of technology innovation leadership competences. Some measure of caution is applied for the following reasons:

- The ILQ is based upon a conventional, linear and sequential four-step innovation process model which differs substantially from the capability cluster framework adopted for this study.
- The ILQ was not specifically designed for technology innovation leaders, which means that there may be technological innovation-related requirements of innovation leaders that do not appear on the ILQ list of leader behaviours or competencies.

3.7.3.8. Hill's collective genius

In what may become known as a seminal contribution to the field of innovation leadership, Hill *et al.* (cited in Girard, 2014) claimed that "conventional leadership won't get you innovation". This claim is based on case studies of 16 highly-successful innovation leaders that appear to include business innovation and technology innovation leaders.

The following key insights were derived from their work during an interview with the author:

- Leaders create collaborative organisations based on teamwork.
- Leaders foster discovery-driven learning.
- Leaders support and encourage integrative decision-making.

Hill *et al.* (2014:x) claimed that in 1999:

> *It was time for me to get serious about re-examining our image of the ideal leader and figure out what it takes to lead the innovation...Then, in 2014, we found among leaders a widely shared, mistaken assumption that a good leader in all other respects would also be an effective leader of innovation. The truth is, leading innovation takes a distinctive kind of leadership, one that unleashes and harnesses the 'collective genius' of the people.*

According to the authors (Hill *et al.,* 2014), the most distinguishable insight from their studies is that successful innovation leaders recognise that innovation requires teamwork and not the act of a sole inventor. "Truly innovative groups are consistently able to elicit and then combine members' *separate slices of genius* into a single work of *collective genius"*. Over three decades of research they clearly found that innovation is most often a group effort.

Thomas Edison, as an example, is often referred to as a great inventor of the early 20th century. His extensive range of inventions included the light bulb and the phonograph and more than a thousand other patented inventions over a sixty-year career. But he seldom worked alone. Edison's greatest contribution may have been the artisan-oriented shops that he established as a new way of organising for collective innovation that has evolved into today's R&D laboratory with its team-based approach. Innovation needs to be collaborative because innovations most often arise from the interplay of ideas that occur during the interactions of people with diverse expertise, experience, or points of view. For some, flashes of insight may play a role, but most often they simply build on and contribute to the collaborative work of others. While Edison may get the credit for his inventions, each one arose from years of effort that included many others. Certainly, he must have contributed many ideas himself, but he was equally an inventor and a leader of invention.

Hill *et al.* (2014:191) claimed that the innovation leader must focus on two areas for harnessing collective genius in innovation. Firstly, focusing on creating conditions in which people are *willing* to do the hard work of innovation with its inherent paradoxes and stresses, building a community with a sense of shared purpose (reason for existence), values (what is agreed as important) and rules of engagement (how to interact with each other and think about problems), which is graphically illustrated in Figure 3.27.

Technology innovation leadership is not static and varies in correspondence with customer needs, technology needs and group needs (Osei, 2014).

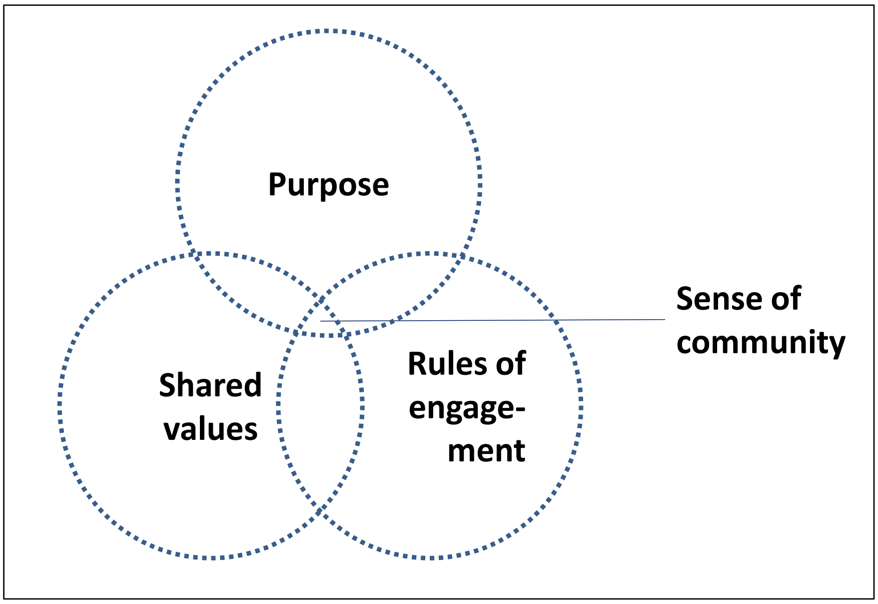


Figure 3.27: Team willingness to innovate

Source: Adapted from Hill *et al.,* 2014:192.

Secondly, the innovation leader must create an organisation in which people are *able* to innovate by building three organisational capabilities essential to innovative problem-solving, namely: (i) creative abrasion (the ability to generate ideas through discourse and debate); (ii) creative agility (the ability to test and experiment through quick pursuit, reflection, and adjustment), and (iii) creative resolution (the ability to make integrative decisions that combine disparate or even opposing ideals) as outlined in Figure 3.28.

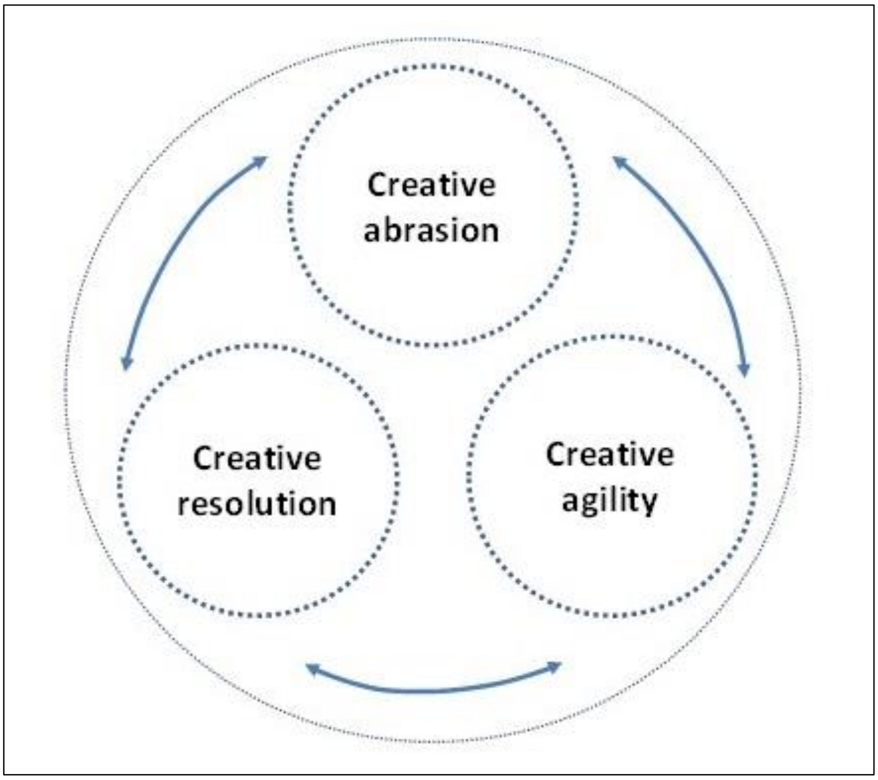


Figure 3.28: Team ability to innovate

Source: Adapted from Hill *et al.,* 2014:192.

3.7.3.9. Special Forces approach to a leadership framework for technology innovation

Dugan and Gabriel (2013:76) claimed that traditional approaches to corporate research and development fail to consistently deliver breakthrough innovations. They proposed a “special forces” approach as indicated in Figure 3.29, based on the Defence Advanced Research Projects Agency that has produced an unparalleled number of technology innovations over 50 years. These innovations include the Internet, RISC (reduced instruction set computer) computing and global positioning satellites. Dugan and Gabriel (2013) claimed that this approach to innovation delivers success because their leadership practices contain key success elements like tackling projects that advance science and technology and solve significant problems, assembling the best minds from industry and academia to create diverse, agile and scalable teams, and allowing independence of the team from the mainstream organisation in project selection and execution.

Based on the approach of Pasteur, who conducted research that advanced basic science while addressing pressing societal needs, Dugan and Gabriel (2013:78) explained that their Special Forces approach to innovation, as illustrated in Figure 3.29, may have significant implications for how many companies conduct their R&D and technology innovation.

In terms of technology innovation leadership implications, the following competencies were derived from the Special Forces approach, as well as some potential technology innovation that competencies can be derived from their explanation:

- Focus on discoveries with the potential to upset current market and business trajectories. Smaller temporary independent innovation teams can prevent technology surprises by creating the conventional linear model of technology innovation implied basic research, followed by applied research that connects new discoveries to a practical end, followed by commercialisation of products that make use of the new technology and manufacturing at scale. The Pasteur approach does not rely on roadmaps.
- Recognise when a scientific field has emerged or reached an inflection point where it can solve, often in a new way, a practical problem of importance (Dugan & Gabriel, 2013:78).
- Uncover emerging user needs that existing technologies cannot address.
- Instil discipline in project selection and execution through a portfolio of innovation projects with a healthy balance between new possibilities created by scientific advances and projects that focus on solving of problems through new scientific development.
- Revise and clarify innovation goals, execution plans and technical challenges to adjust their capabilities and resource requirements in light of new discoveries.
- Plan and track project progress to allow for fast review and adjustment iterations that review convergence on goals, reveals dead-ends, changes the risk profile and uncovers new applications or unforeseen scientific advances. Dugan and Gabriel (2013:79) warned that the typical methods used for planning and tracking product development projects are not well suited to the Pasteur approach.
- Encourage learning and new insights from setbacks and failures.
- Agree with team members and stakeholders that an innovation project might be shut down and resources shifted to other approaches if the science does not work, the pace is slower than other projects or new ideas and a solution to making it work cannot be found (Dugan & Gabriel, 2013:80).
- Use temporary teams and apply time limits. Dugan and Gabriel (2013:80) claimed that one of the most effective ways to attract talented performers from various disciplines, organisations and backgrounds, and to keep them intensely focused, is to set a finite project term and staff it with people working under contracts that last only as long as the jobs they perform contribute to the overall goal.
- Review and adjust innovation team compositions as the team overcomes certain obstacles and others emerge.
- Maintain a sense of urgency through clearly articulated important needs and scientific challenges that force the team to act as a whole, benchmark progress and continually challenge “how things have always been done”.

- Orchestrate the entire effort, including establishing work needed to produce a specific result, conduct a proposal competition and appoint subcontractors from academia, government labs, corporations and non-profit organisations (Dugan & Gabriel, 2013:81).
- Demonstrate deep technical or scientific knowledge and be a natural risk taker.
- Be a thought leader who can create a vision that inspires an entire community (Dugan & Gabriel, 2013:81).
- Oversee the collection of performers, manage the technical details and make all major decisions, handle budgets, contracts, execution issues, speaking engagements and customer relations. This may include technical talks at a research conference or working out IP concerns with a university.
- Radiate confidence. Many have PhDs, are in their 30s or early 40s, had previous innovation success, like taking a product to market, leading a research centre or starting a company. Some have MBAs and can use business school skills like formulating a plan and faithfully executing it. These project leaders focus more on managing constant flux, building, re-planning, changing tack and moving talent in and out as project needs evolve.
- Attract talent in service of the country. The Special Forces approach offers the honour of being asked to work for an elite organisation with a storied history and the opportunity to pursue something amazing, often counter cultural.
- Challenge an entire industry or analyse the formation of one. The Special Forces approach gives exceptional leaders an environment where they can pursue what others may think is a crazy idea.
- Rock the boat without jeopardising their careers as their focus is on changing the world.
- Design structures and deal with obstacles to allow for speed and momentum.
- Network with other enthusiastic qualified candidates.

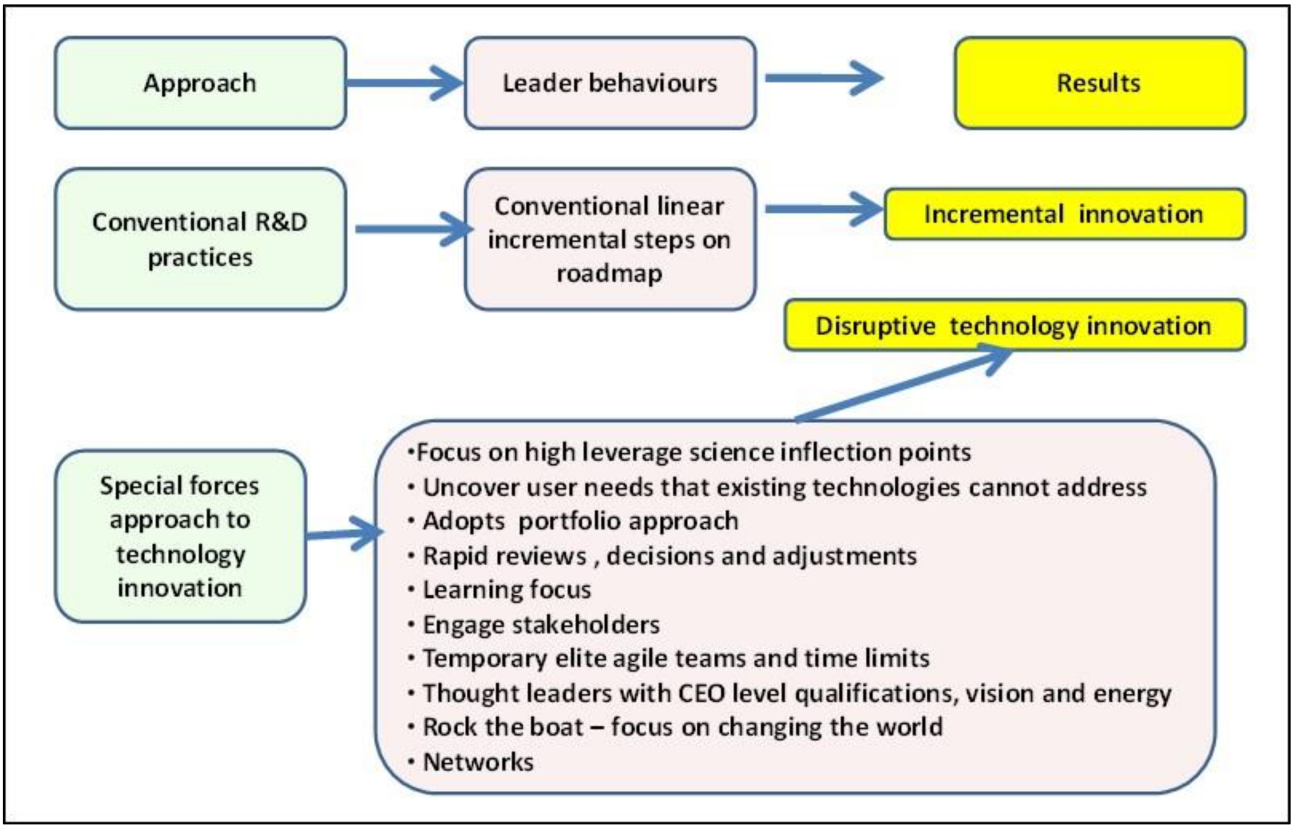


Figure 3.29: Special Forces perspectives of Dugan and Gabriel

Source: Dugan and Gabriel, 2013:78.

3.7.3.10. Integrative leadership

Integrative leadership was related to the path-goal theory by Youn, Yang and Hong (2012) whose research suggests that integrative leadership which is congruent with specific goals in the supply chain domain, positively influences supply chain implementation outcomes. The theoretical framework developed by Youn *et al.* (2012) is based on psychology literature in which they claim that goal congruence is crucial for person-organisation fit and performance outcomes. "The more organisational goals are shared among employees, the more employees are motivated. Individual employees are likely to commit to organisations when their preferences are congruent with organisational goals" (Youn *et al.,* 2012:238). Goal congruence further suggests that decision-makers collaborate for shared objectives and goal congruence at project level, which is seen as motivator of project success. More challenging goals lead to better quality coordination and in-process planning among team members and such goals allow team members to select activities that are relevant to the valued outcomes. Goal congruence in networks also reduces potential conflict between members and enhances synergistic knowledge-sharing practices between partners (Youn *et al.,* 2012).

Rothaermel and Hess (2007:898) warned against single-level analysis when heterogeneity is not observed, such as when studying the dynamics of technology innovation in a "more or less homogeneous group of firms or industry" and neglecting heterogeneity in multiple forms that may enhance interdependency. In their sample of global pharmaceutical firms only 0.5 percent of all staff could be described as "intellectual human capital ... highly skilled and talented employees ... as research scientists that publish in academic journals" that can be "heterogeneously distributed across firms..." (Rothaermel & Hess, 2007:899).

Rothaermel and Hess (2007:899) referred to "tacit knowledge resulting from the interaction of highly skilled human capital" that may be "a unique source of innovation competence" such as scientists creating deeply-embedded knowledge that is difficult to transfer or imitate. Firms that can identify an "exogenous paradigm shift, and then assemble the requisite human assets..." will develop the dynamic innovation capabilities necessary to succeed and "managers who take a discerning and discriminating approach towards selecting innovation mechanisms, will be most successful in building the dynamic capabilities necessary to continuously innovate" (Rothaermel & Hess, 2007:916-917).

It should be clear from the preceding discussion that the integrative skills of the technology innovation leader would have to be considered as a competency set that may be required for successful technology innovation, in addition to their other competencies as a highly skilled minority group.

3.7.4. Section synthesis/Implications of reviewed leadership theories and perspectives for this study

The study of leadership seems to have evolved over time to move away from the study of leaders, their traits and their styles to use different power bases to get people to achieve predetermined objectives. Leadership in innovation environments appear to be significantly more team focused where the leader's competencies are instrumental in creating environments where people want to and are able to contribute to innovation success, which is explored in the next discussion.

3.7.5. Specific leader competencies related to capability clusters

The literature review revealed insights that will be discussed in following capability areas.

3.7.5.1. Capability to connect with evolving science and technology

More leaders are becoming involved in ideation and idea management to ensure alignment with strategy (Arthur D. Little, 2015). Leaders are tapping into sources of inspirational ideas, including customers, new technology developments and insights into future market needs driven by megatrends (Arthur D. Little, 2015).

Leaders should be able to identify and anticipate the changing nature of markets by focusing on possibilities and being willing to take a stand that may create a conflict or be unpopular and encouraging these behaviours in others (Kaplan and Norton, 2004: 292-295). Technology innovation leaders are significantly more likely to spend their time on activities that are strategic to the business (Whitehurst, 2014:5). They maintain informal social networks for communication, integration, flexibility and novelty within and between organisations (Conway & Steward, 2009:323). According to Miller *et al.* (2012:2), “the absence of a well-articulated innovation strategy is by far the most important constraint for companies to reach their innovation targets, followed by a lack of understanding of the external environment”. Miller *et al.* (2012) claimed that such a strategy should be developed in a bottom-up manner to focus on people as key source of competitive advantage.

The preceding discussion confirms that in the rapidly-changing, unprecedented and volatile environment in which innovation leaders operate, successful leaders rely increasingly on their own judgment to make decisions (Insead, 2014). Their systems-thinking is important to understand the relatedness and interconnectedness of things to accommodate systemic innovation and to anticipate unintended consequences (Buijs, 2007). Senge (2008) combined systems thinking, collaboration, and team learning in what he called the “Learning organisation” which is:

> *[one in which] people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning to see the whole together.*

3.7.5.2. Capability to align stakeholders’ support

Leaders in technology-focused firms competing in rapidly-changing and evolving environments ensure teamwork, share a clear vision and strategy, provide information, knowledge and methods to realise that vision and share, coordinate and balance conflicting interests of all members and stakeholders (Bruton & White, 2011:113). Leaders gain credibility by demonstrating strong technical domain skills complemented by leader skills (Bruton & White, 2011:285)

They shift collective focus from reactive problem-solving to co-creating the future beyond just building inspiring visions, by facing difficult truths about the present reality and by learning how to use the tension between vision and reality to inspire truly new approaches (Senge Hamilton & Kania, 2014). Collective or collaborative innovation is becoming an important approach for leaders who are responsible for innovation (Hill *et al.,* 2014; Baumgartner, 2010; GE, 2014).

Table 3.11 shows a comparison between traditional leaders and creative collaborative leaders done by the American Creativity Association (Reisman, 2014:12) to indicate the changing role of innovation leaders throughout the innovation process.

Table 3.11: Comparison of traditional versus collaborative leaders

Element	Traditional leader	Creative collaborative leader
1. Power	Positional power of the leader is based on position of authority	Encourages participation across all levels
2. Information	Shared on need-to-know basis to retain authority and control	Open information sharing
3. Idea generation	Top-down	Open to suggestions and ideas from the team and recognises that different perspectives bring new insights
4. Problem solving	Top-down decisions	Recognises the power of a group approach to problem-solving
5. Resource allocation	Only provided when deemed necessary by the boss	Based on trust and may be delivered pro-actively so that team has access to time, money and equipment to do their jobs efficiently
6. Rules and responsibilities	Adheres to specific roles and responsibilities that may stifle the creative process	Encourages teams to work together and to share information, resources, knowledge, time and effort
7. Resolving issues	Often addressed at individual level with no regard to root causes of the problem	Focuses on trust and looks for root cause of conflict as it arises, addresses solutions promptly to keep work moving forwards
8. Performance and feedback	Once or twice per year as per corporate policy	Environment allows leaders and team members to work closely together daily, allowing immediate feedback, praise and constructive criticism

Source: Reisman, 2014:12.

Their innovation learning is based on interaction with all stakeholders to create superior value based on entrepreneurial values driving enquiries, knowledge and innovation. Power relations are deemed ineffective (Steyn, 2012:69) and through the framing instead, mindsets regarding innovation at work accommodate spontaneous emergence of solutions through innovation.

3.7.5.3. Capability to liberate mind sets

Arthur D. Little (2015) revealed the findings of their global best practices study, one of which is a shift towards innovation leaders becoming more involved in idea management. Leaders devote significant time towards idea management for the “development of a ‘radical’ mindset - flexible and open to opportunity without imposing unnecessary constraints”, and do so for ideation from start to finish (Arthur D. Little, 2015). While others are still using ideation techniques to generate ideas in line with their strategies and tapping into the creativity of their people, the pioneering best practices aim for the emerging of ‘killer ideas’ (Arthur D. Little, 2015). These leaders nurture multiple cultural approachesand leverage lessons learned from failing (Arthur D. Little, 2015).

Leaders apply innovation and risk-taking to create new value by applying breakthrough thinking by challenging conventional thinking, identifying and developing new solutions and fostering creativity and innovation (Kaplan & Norton, 2004). Dyer *et al.* (2011) claimed that discovery skills of the leader include associational thinking, questioning, observing, networking and experimenting which are all focused on the front-end of the innovation process related to identifying new opportunities.

The leader adopts a leapfrogging mindset – focusing on creating or doing something radically new or different that adds a completely new level of value, surround themselves with diverse team members, continually expand their mindsets and creative problem-solving abilitie, they continually push the limits of their teams, organisations, and partners (Innovation-point.com, 2014). Leaders reframe conventional mindsets and adopt collaborative technology to drive value innovation with shared systems. Current organisational leadership requires new competencies for improved innovation management (Steyn, 2012).

3.7.5.4. Capability to facilitate value creation

Elkins and Keller (2003) found intellectual stimulation to be one of the most important leadership behaviours to stimulate innovation performance of others. Tidd and Bessant (2013) later concurred with this view and added that intellectual stimulation is one of the most underdeveloped leadership components to increase others' awareness of and interest in problems, and develops their propensity and ability to tackle problems in new (innovative) ways.

Innovation leaders nurture high-value yielding practices through trend monitoring and business intelligence, adopting agile processes and tools with fast iteration cycles, actively managing the innovation ecosystem (Arthur D. Little, 2015). To create new value they challenge assumptions and drive innovation by promoting innovations and being open to change, proposing new ways and focusing on possibilities (Kaplan and Norton, 2004).
Leaders recognise that surprises are inevitable during the innovation process and use these to make them agile and fast to capitalise on unforeseen events (Innovation-point.com, 2014).

Innovation is often seen as the work done by specialists in R&D, marketing, design or ICT when the truth is that everyone possesses the underlying creative skills and problem-solving abilities for innovation. Leaders know that, if mechanisms can be found to "focus such abilities on a regular basis across the entire company, the resulting innovation potential is enormous" (Tidd & Bessant, 2013:124). Leaders cause successful innovations seamlessly connecting concepts and ideas to their operational manifestations". In the ICT domain and in today's economy, business and technology have become inseparable where you cannot have one without the other. In ICT, for example, portfolio-level integration is needed for mobile, social and cloud computing (Muller, 2013:148). Diversity of thought and experience is valued in collaborating fluidly across functions, hierarchy and traditional corporate boundaries (Whitehurst, 2014).

3.7.5.5. Capability to facilitate value realisation

The innovation leader integrates data and intuition. Hard data is needed for making important decisions. In times of disruption, however, robust data rarely exists. Leaders must use information they can obtain from any and all sources inside and outside the organisation – but then be comfortable using their gut for the rest (Innovation-point.com, 2014). Innovation leaders balance the present with the future (Drucker, 1982:46) and they achieve organisational effectiveness and sustainability (Government of Canada, 2007:2).

Rooke and Torbert's (2005:45) proposed the leader's 'action-logic' as basis for their developmental model in which a leader can progress from more basic to more sophisticated categories of leadership. These categories, in order of increasing sophistication, are Opportunist, Diplomat, Expert, Achiever, Individualist, Strategist, and Alchemist. Their research findings suggested the latter three being associated with consistent high performance, while the first three were associated with low performance (Rooke & Torbert, 2005:51). They claimed that "the transition from Expert to Achiever remains one of the most painful bottlenecks in most organisations".

The challenge for innovation leaders is to find the right balance and allow space for complementary skills to step in and fill any gaps. For them, great leadership is as much about honesty and humility as it is about focus and inspiration. Innovation-directed behaviour is unlikely to happen unless the values and norms are portrayed in the stories, physical layout, rituals and language of the organisation (Hogan & Coote, 2014).

3.7.5.6. Capability to integrate through leadership

Innovation leaders are systemising breakthrough innovation by defining strategic needs for breakthrough innovation strategies and organising and resourcing to realise breakthrough strategies with accountability in cross-functional organisational models (Arthur D. Little, 2015).

They are role models by taking a stand that may create a conflict or be unpopular and encouraging these behaviours in others, taking risks and directly challenging the assumptions and beliefs of people at all levels (Kaplan and Norton, (2004). Leaders who share a common purpose and role-model the desired behaviours will keep the innovation energy flowing like a river. For them, the best leaders have focus and enable their people to focus. The nature of innovation requires white spaces and unscheduled time which innovation leaders tend to provide. They believe that most great innovations have a story of focus and innovative leaders who ensured that the right ideas were brought into realisation.

Tidd and Bessant (2013:145) also claimed that successful innovation leaders are:

> *...very honest about their strengths and limitations and that they are unafraid to make any gaps in their strengths public. Some people are born enthusiasts – they are brilliant at emphasising the positive and cheering people on. Others make great taskmasters – they do not shirk from giving people bad news or telling people something is not good enough.*

How an innovation leader thinks about innovation leads to personalised "mental pictures" derived "from the leader's understanding of the actions involved in managing innovation," which in turn "affects their ability to improve management of the innovation process" (Tidd & Bessant, 2011:23). Those who view innovation as a simplistic process with most emphasis needed on invention, will organise and manage innovation, resulting in inventions that people do not want. Leaders who are serious about managing innovation, review their mental models to work with as complete a picture as possible (Senge, 2006).

Albrecht (2006) called for a shift in leadership practices that he describes as "a different kind of 'smart'" as introduction to his book devoted to the concept of social intelligence. Albrecht (2006:222) urged leaders to reflect on how they would like to be perceived and warned against power images of "cowboy" leadership (Albrecht, 2006:191) and "attention deficit disorder" (Albrecht, 2006:188). Collins (2001) also emphasised the need for leaders to set a learning climate where the truth is heard, a leadership skill referred to as "conduct autopsies, without blame" (Albrecht, 2006:77).

Senge *et al.* (2014) emphasised leader competencies related to collective leadership as systems leaders, including the ability to see the larger system, rather than parts visible from their vantage point, fostering reflection and generative conversations; and shifting collective focus from reactive problem-solving to collective creativity.

The leader conducts adaptive planning. Leading disruptive innovation requires managing high levels of uncertainty. The adaptive planning approach to leading implies that action leads to results that leaders learn from to modify assumptions and approaches accordingly, and that such learning causes new insights that shape future actions that are even better calibrated to the needs of the market (Innovation-point.com, 2014).

According to Avolio (2007), leadership theory and research needs to move to a next level of integration – considering the dynamic interplay between leaders and followers, taking into account the evolving context – for continued progress to be made in advancing both the science and practice of leadership. Integration is the "process of attaining close and seamless coordination between several departments, groups, organisations, systems..." (BusinessDictionary.com, 2016a). More recently there has been evidence of a leadership paradigm which includes the notion of influencing a group of people, not necessarily employees, to achieve a common goal. From the transactional paradigm developed by Bass in 1985 (cited in

Almonaitiene, 2013:55), the "new" leadership paradigm has emerged from the work of scholars to place more emphasis on neo-charismatic, transformational, visionary, and, lately, authentic leadership theories.

Muller (2013:72) sees innovation leaders as creating a culture of innovation with networked intelligence that is underpinned by five principles, namely: (i) collaboration: (ii) openness; (iii) sharing; (iv) integrity; and (v) interdependence.

According to Hoque (2013), the Aspen Institute's Economic Innovation Roundtables concluded in 2009 that innovation, to be effective, required leadership impact that stems from collaboration, vision, and, above all, the will to direct progress for long-term growth. Hoque (2013) referred to studies that attributed 85 percent of financial success to leadership and 15 percent to technical knowledge.

Bapat *et al.* (2004) investigated leadership competencies for innovation and provided examples of how their findings apply to an innovation leader in a technology innovation field, as well as an innovation leader in a business service innovation. They emphasised creativity, enterprising, integrating perspectives, forecasting and managing change. Michigan University (2014) identified a list of management and leadership competencies that included the following competencies in their innovation section:

- Is receptive to new ideas and adapts to new situations;
- Exhibits creativity and innovation when contributing to organisational and individual objectives;
- Takes calculated risks;
- Seeks out opportunities to improve, streamline, reinvent work processes;
- Helps others overcome resistance to change;
- Thinks expansively by combining ideas in unique ways or making connections between disparate ideas;
- Explores numerous potential solutions and evaluates each before accepting any, as time permits;
- Targets important areas for innovation and develops solutions that address meaningful work issues;
- Develops new products or services, methods or approaches;
- Sponsors the development of new products, services, methods, or procedures;
- Develops better, faster, or less expensive ways to do things;
- Creates a work environment that encourages creative thinking and innovation; and
- Adapts best practices and processes to the work unit.

Their innovation approaches are structured and managed – but speed is valued over perfection and they cut through bureaucracy (Whitehurst, 2014). They invest in and reward innovation (Whitehurst, 2014).

Following a critical review of the nature and importance of leadership and leadership theory, Gill (2011:xv) concluded that influence, motivation and inspiration are elements of engagement regarded by the author as one of the six recurring themes and practices. The other five themes and practices encompass vision, purpose, values, strategy and empowerment. Gill (2011:xvi) suggested that these core themes could be viewed as working together across leadership practices, concepts, and theories.

Ashlubolagh *et al.* (2013: 2203) identified innovation leadership behaviours such as innovative role-modelling, intellectual stimulation, stimulating knowledge, providing vision, consulting, delegating, support for innovation, organising feedback, recognition, rewards, providing resources, monitoring and task assignment. Ashlubolagh *et al.* (2013:2201) reported the impact of middle-level managers' leadership styles on innovation by regular workers in a manufacturing environment. The authors claimed to have found that all leadership behaviours observed have influenced innovation. They claimed the most important influencing factor to be the stimulation of knowledge diffusion, followed by intellectual stimulation and thirdly, innovative role-modelling. Le Storti (2003:157) added that there is a difference between a creative leader and a leader of creativity, suggesting that the latter achieves better creative team performance, while the first tends to create team dependency with members waiting for the leader to make decisions.

Kingdon (2012:135-141) claimed that "the best innovation environments are not created through traditional management channels but are self-organised". According to Kingdon (2012), buildings can be designed, as in the case of Pixar's Steve Jobs, for increased probability of innovation based on serendipity by putting mailboxes, meeting rooms, the cafeteria and bathrooms in the centre of the building so that people would have contact on a daily basis. According to Kingdon (2012), Steve Jobs "...realised that when people run into each other, when they make eye contact, things happen".

A leading international innovation consultant claims to have studied thousands of innovation projects over a 16-year period from which he concluded that, "Innovation energy" had been the single most important contributor to the innovation success (Tidd & Bessant 2013:141-145). 'Innovation energy' is described as the confluence of three forces, namely: (i) the individual's attitude; (ii) the group's behavioural dynamics; and (iii) organisational support. They claimed that leaders who realise that the innovation is ultimately about getting the best out of people are the ones that go beyond traditional business concepts to liberate the potential of people.

3.7.6. Conclusion and section synthesis

Technology innovation leader competencies that were observed in literature, were linked to the capabilitiy clusters of the provisional conceptual model (Figure 1.6). From the competencies mentioned, it appears that these leaders require a blend of competencies that may not fit conventional ways of grouping people around prededertimed work. Technology innovation leaders liberate people's thinking and contributions towards conceiving and realising possibilities. These leaders let people contribute through more than what they were trained and appointed to do.

In what may be one of the first books published on the management of innovation, Burns and Stalker (1961) described a world in which the organisation was viewed as a collection of workers. The functions of each manager and worker were clearly specified at levels which they were expected to follow, and where they followed instructions issued in a steady flow from the general manager down through the organisational hierarchy. The system, lubricated by paternalism worked smoothly and economically and there was no evidence that individuals felt aggrieved or belittled. The R&D laboratory that typically formed part of the system had suffered from "comparative impotence" because it mainly responded to enquiries from their head office (Burns & Stalker, 1961:2). Their activities were regarded with suspicion and hostility because they were formally responsible for introducing new products, solving problems and curing faults that people working in those areas were not allowed to do.

Nearly 40 years later in the third print edition of the same book, Burns and Stalker (2000: vii) observed that political, economic and social circumstances had undergone radical change and that the horizon of possibilities and expectations had also changed significantly. Worker motivation became more important and was now seen as a balance between satisfaction and expectation, given the limited capacity of humans to deal with increasingly complex problems. Organisational studies also revealed the inadequate practices of managers who based decision-making on known alternatives presented in constantly-recurring situations and to only search for new possibilities and setting wider boundaries for problem-solving when "programmed decision-making" failed to meet requirements (Burns & Stalker, 2000:xiii). Differences became more noticeable between managers who saw the organisation as a "mechanistic" entity, as opposed to those who saw an "organic" entity in which authoritative instruction by management was less dominant and hierarchical order of rank less obvious for those involved in technical innovation (Burns & Stalker, 2000:xiv).

The above insights link to profound claims by Burns and Stalker (2000:xxi) that, "when novelty and unfamiliarity in both market situation and technical information become the accepted order of things, a fundamentally different kind of management system becomes appropriate from that which applies to a relatively stable commercial and technical environment".

Hill *et al.,* (2014:1-2) argued that leading innovation takes a distinctive kind of leadership; one that unleashes and harnesses the "collective genius" of the people through the following abilities (Metcalf, 2014):

- Seeing different perspectives;
- Aligning multiple perspectives;
- Dealing with ambiguity;
- Dealing with complexity;
- Being flexible and adaptable;
- Learning about different ways of doing business;
- Living outside a comfort zone;
- Managing multiple priorities;
- Thinking beyond the borders; and
- Understanding the impact of one's decisions

Other things being equal, technology innovation teams whose leaders are unable to "talk the language of marketing, engineering, and manufacturing" and thus unable "to exert influence upon the engineering, manufacturing, and marketing functions", will have a lower probability of success (Schilling, 2010:272).

3.8. TECHNOLOGY INNOVATION SUCCESS PERSPECTIVES

This study aims to identify technology innovation leader competencies deemed to be required for successful technology innovation. This section expands the preceding theoretical reflections on competencies, innovation, innovation processes and leadership to include a review of perspectives on successful technology innovation.

High failure rates in the technology innovation field have been acknowledged as one of the reasons why senior management and established organisations are reluctant to adopt innovation in their strategies and cultures (Conway & Steward, 2009). 'Failure' means lack of success, an unsuccessful person or thing, a situation in which something stops working properly or an instance of not doing something that is expected (Oxford Dictionary, 2009:335). In this study the latter interpretation applies as it relates directly to the research aim of this study, which is to identify technology innovation leader competencies deemed to be required for successful technology innovation.

3.8.1. Perspectives on technology innovation successes

In Chapter 3 'innovation' was defined as the process of turning ideas into reality and capturing value from them – and only if we can manage the whole process, is innovation likely to be successful (Tidd & Bessant, 2013:21). Technology was defined as the application of scientific knowledge for practical purposes in the form of machinery or equipment developed from this knowledge (Oxford Dictionary, 2009:954). Successful technology innovation thus suggests not only the creation of technology, but also its implementation or adoption and capturing value from them. Performance evaluation includes "...the selection and effective use of evidence of progress and results" (Greenfield, Williams & Eiseman, 2006:21). Value indicators for technology innovation success in the National System of Innovation (NSI) of South Africa include technical, business, as well people-related value derived from technology innovation (RSA, 2013a).

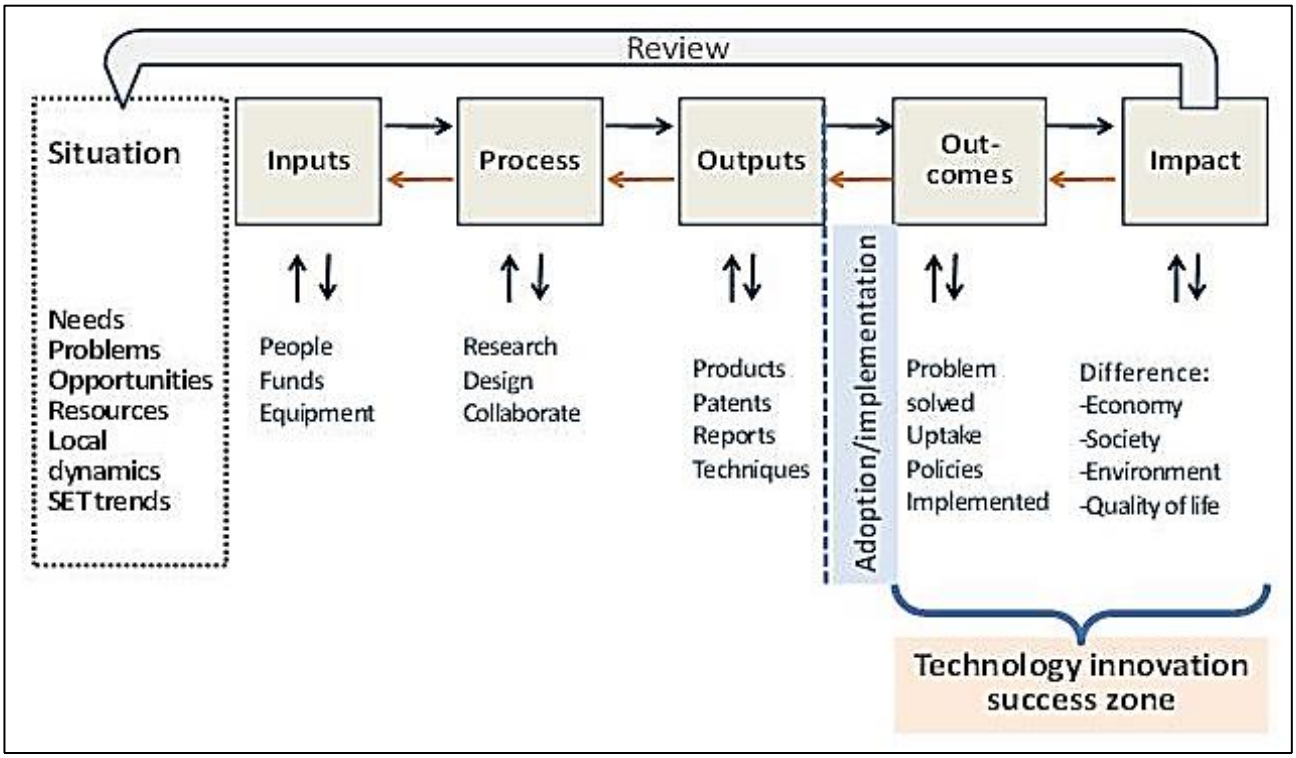


Figure 3.30: Technology innovation success zone

Source: Adapted from CSIR, 2010.

This study aims to identify technology innovation leader competencies deemed to be required for successful technology innovation. It should be clear from the preceding discussion that the determination of success metrics falls outside the scope of this study.

To guide the identification of technology innovation leader competencies, successful technology innovation in this study thus refers to a range of value indicators that can only manifest upon adoption or implementation of technology and this range is described as a technology innovation success zone in Figure 3.30.

Technology readiness levels represent a concept developed by the National Aeronautics and Space Administration (NASA) (2013) to indicate the level of maturity that a technology has reached in terms of its implementation readiness for adoption by the intended users of technology as indicated in Figure 3.31.

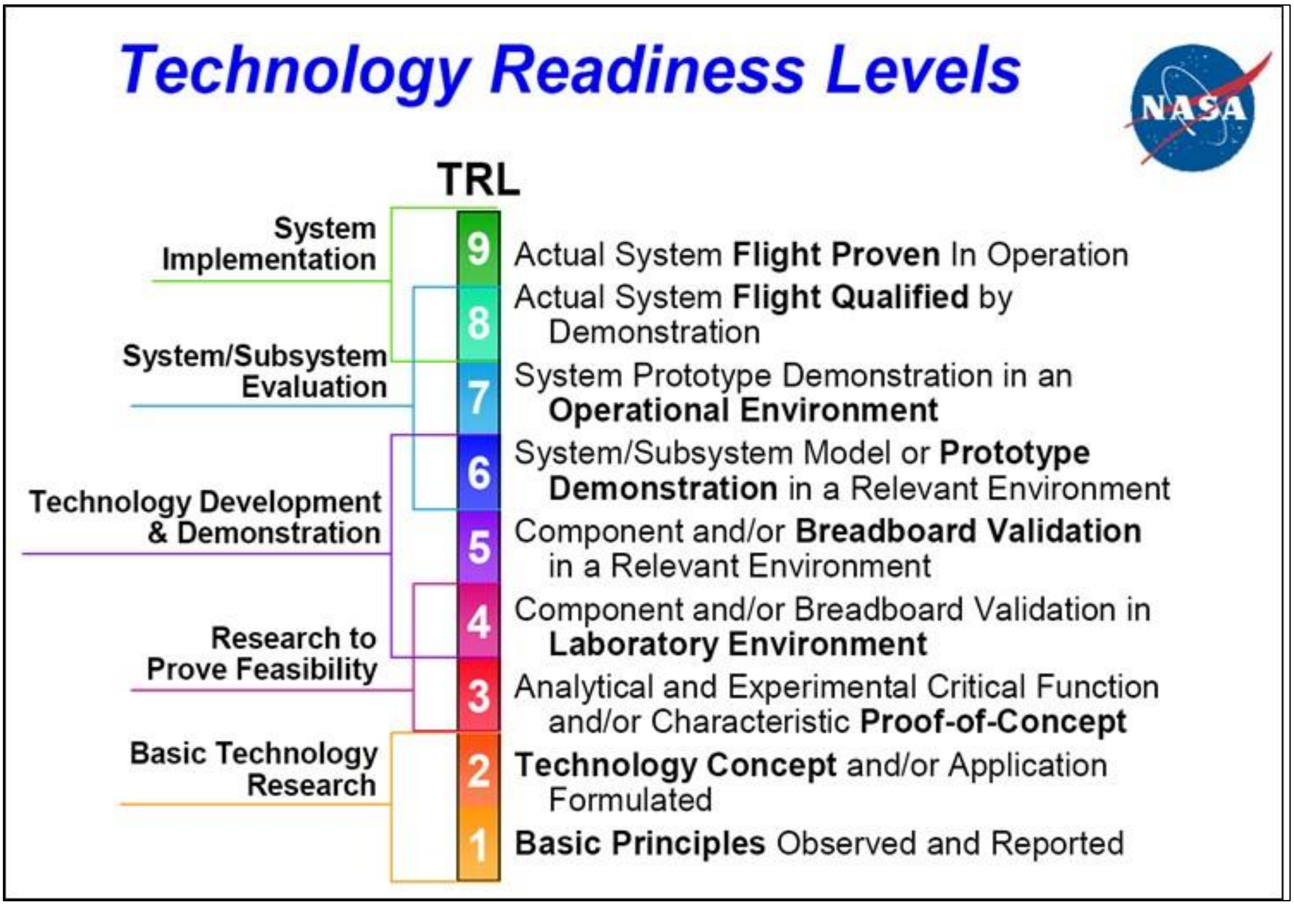


Figure 3.31: Technology readiness levels

Source: NASA, 2013.

3.8.2. Perspectives on technology innovation failures

This research aims to establish technology innovation leadership competencies that are deemed necessary for successful technology innovation. While successful innovation is being explored, competency-related insights may also emerge from considering reasons why technology innovations fail, because these insights may lead to better understanding of the role of technology innovation leadership competencies in bringing about successful technology innovation.

Several authors have commented on high failure rates for technology innovation and claim that a better understanding of failure might be as important as understanding success (Balmaekers, 2014). Conway and Steward (2009:278) referred to studies that found 30 to 95 percent of original ideas do not reach a market launch stage. Schilling (2010:5) found that, despite poor success rates of innovation initiatives, little research has been done on causes and possible remedies for such failure. While not specific to technology innovation, Richards (cited in Balmaekers, 2014) claimed to have distinguished, with the MIT Innovation Lab, the leadership-caused conditions associated with innovation failures as listed in Table 3.12.

Table 3.12: Leadership-caused conditions associated with innovation failures

Organisational	Internal process	External engagement
No explicit innovation agenda	Unclear goals, expected results & timing	Weak customer engagement
Lack of clear overall purpose	Inadequate resources applied to deliver results on schedule	Failure to differentiate between users, choosers & influencers
Inadequate customer focus	Inadequate business case for proposed ‘innovation’	Sales or market channels not engaged early & often
People disengaged from strategy	No early feasibility check	Inadequate market research
Weak leadership	Lacking or ineffectual executive champion	Suppliers not engaged or fail to deliver on requirements
People organised in silos	Weak project leadership	Market or industry experts disinterested or negative
Disempowering, blame culture – experimentation not encouraged	Ineffective teamwork, communication & collaboration	Competitor(s) not understood or response not anticipated
Intellectual communication prevalent & tolerated	No celebration of milestones	Other innovations or trends make the idea irrelevant
Collaboration & contribution inadequately rewarded	Design not involved throughout	Regulatory environment precludes or limits acceptance
Little or no design competence	Little or no usability testing	Too many variable alternatives
Inadequate business intelligence on customers, markets, competitors & industry trends	Inadequate monitoring & evaluation of results	Can’t command adequate price
Lack of systemic knowledge management	Failure to terminate failing projects	‘Innovation’ rejected by customers

Source: Adapted from Richards, cited in Balmaekers, 2014:4.

Muller (2013:140) added that the innovation culture of a firm should allow innovation “all over the place” and where people are innovative all of the time. The traditional way of thinking about innovation was to think of it as a special activity. Firms that still view innovation like that are likely to experience failure, because people will offer excuses for not being innovative, like a lack of budget, or that they do not have time. Muller (2013:140) pointed out that Steve Jobs had often given his innovation teams near “impossible” innovation goals with “impossible time frames” and other “restrictions and constraints” that resulted in success rather than failure.

3.8.3. Success orientation

The term ‘success orientation” was not mentioned in communication with respondents but chosen by the researcher as a term for expressing the assumed relationship between what the responding technology innovation leader views as successful technology innovation, and the alignment of the leader’s competencies with that success view. While the concept may be new in a study of this nature, the descriptor appears to be used in studies in other fields, came from Strategic orientation, market orientation, Success measurement by considering the impact of innovation on society, the environment or stakeholders are important but often neglected emerging areas in the study of management and organisations (Conway & Steward, 2009), which presents a challenge for conducting research where success orientation is used as an independent variable, such as this study. Some scholars have shared insights on the approach or attitude of technology innovation leaders.

Measuring the success of technology innovation may involve the use of highly sophisticated metric and instrument because technology innovation can be found in product innovation, process innovation, position and paradigm innovation, and it can be incremental, modular, architectural or radical, according to Tidd and Bessant (2013:24,42). Measuring technology innovation may focus on any one or more of these areas, it can be measured at different times, and may include or exclude a range of complex issues that are not within the scope of this study (Tidd & Bessant, 2013:445).

Innovation studies often focus on cases of success, but seldom explicitly outline their measures of success and when they do, they mostly apply the perspective of the innovating organisation and are favoured towards products produced in industrial or manufacturing settings (Conway & Steward, 2009). Measuring innovation success is not unproblematic, therefor, because it often involves assessments of the degree to which innovation is viewed as novel, adopted or diffused and these can be judged in different ways and from different perspectives of those involved over different timelines (Conway & Steward, 2009). However, despite the measurement challenges involved, innovation success can only be measured against criteria that those involved regard as success criteria and this creates even greater challenges when the role of innovation is considered at sectoral, national or global levels (Conway & Steward, 2009). In practice, a range of criteria is typically used in combinations that might include (Conway & Steward, 2009:24):

- Technical, e.g. design elegance, performance and functionality;
- Market, e.g. adoption or penetration;
- Financial, e.g. return on investment;
- Strategic, e.g. competitive advantage through development of superior offerings or technical capabilities or competencies; and
- Process, e.g. time taken to market introduction.

Successful innovation requires the leader to anticipate a strong association between carrying out an innovation accomplishment and employing a participative-collaborative style of leadership (Kanter, 1997:107).Such leaders persuade others rather than ordering them, building teams where people interact frequently and share information, they seek inputs from others (users, subordinates, peers, etc) all the time, they acknowledge others' stake or potential stake in the project (politically sensitive) and they share rewards and recognition willingly (Kanter, 1997:107). While collaborative work is encouraged in most work situations, traditional autocratic practices may suffice, but for innovation it is very important as the leader seeks funds, support, information, and more. These additional contributions are often required outside normal working hours and requires "above and beyond" effort from all involved, which necessitates competencies related to the willingness of the leader to participate, collaborate and persuade (Kanter, 1997:108).Such practices helps the innovation leader to reduce risk because it encourages completion of the innovation assignment, and involves others who would otherwise be judges of innovation performance to assist through involvement checks and balances, reshaping it to make it work, and putting pressure on other people to support successful innovation (Kanter, 1997:108).

Successful technology innovation requires various individual "slices of genius" to be converted into novel and useful value manifestations which no individual could provide alone,and starts with a "blank slate" but each creator's final input must be "consciously chosen, created, and inserted" (Hill *et al*,. (2014: 11) The leader has to accept the challenges to be overcome, such as understanding that the reduction of innovation to a simple diagram with "simple series of steps" that "different groups take in a neat, sequential way" might fail "to communicate how iterative, and interrelated – in short, how messy – the steps of the process are" (Hill *et al*,. 2014:13).

The term 'orientation' is used to describe a person's attitude or inclination towards something (Oxford, 2009), which in this study means what the technology innovation leader regards as success in terms of what stakeholders defined as success. In South Africa, innovation success indicators appear in policy, strategy and planning documentation of the Department of Science and Technology (DST).

From the preceding discussion, it can be concluded that innovation success measurement is not a simple matter. The technology innovation leader's view of what success entails is thus important to establish the competencies deemed to be required for successful technology innovation, which is the aim of this study.

In this study respondents were asked to indicate the extent to which they agreed with a definition that technology innovation is only achieved when value is derived from its adoption or deployment. The research results presented in Chapter 6 showed a 79 per cent agreement (50% strongly agree plus 29% agree) that technology innovation is only achieved when value is derived. Respondents were also requested to indicate the extent to which 10 success indicators reflected their personal views of what successful technology innovation entails. The resulting use of success orientation as a construct and independent variable for this study was therefore assumed to be sufficiently representative of what the respondent views as successful technology innovation.

3.9. THEORETICAL FRAMEWORK FOR RESEARCH

3.9.1. Limitations of current theory

Innovation is a complex phenomenon that embraces several academic disciplines and the field needs new theory. The field brings together science, technology and socio-economic aspects and this overlap makes it necessary to have a body of theory that can aid and assist in analysing the phenomenon (Smith, 2010:68). Anderson *et al.* (2014:1318) revealed a relative lack of theoretical advances across creativity and innovation literatures and claimed that "...there remains a real need for more, and more radical theory-building contributions". Theories should be statements "...about how things are connected" and are "...created by developing sets of propositions or generalisations which establish relationships between things in a systemic way" (Henning *et al.,* 2004:14).

From the theories and theoretical perspectives reviewed, it appears that further contributions to theory may be required in the following main areas, to answer the research question:

- Technical skills and environmental scanning at the onset of the process,
- Integration of multiple stakeholders,
- Non-sequential progression through context-specific stages; and
- Involvement of the consumer in commercialisation or technology adoption stages.

For Sen (2011) and Sutherland (2013), conventional management practices seem inadequate for innovation leaders' challenges. They claimed that solutions to the range of problems, challenges or opportunities experienced by innovation leaders are unlikely to emerge from the management practices that caused them (Sen, 2011; Sutherland, 2013). They are also unlikely to be solved in a short time with incremental changes or conventional management (Sen, 2011; Sutherland, 2013).

Based on experience rather than research, another perspective comes from Lafley and Charan (2010) who claimed that innovation cuts across all established aspects of the organisation and how it is managed. They suggested that innovation has become the key to shaping corporate life by allowing leaders to conceive previously unimagined options for customer attraction, for staying ahead of competitors, and that new ways are emerging for it to be mapped, systemised, managed, measured and improved to bring about a steady stream of innovations (Lafley & Charan, 2010).

Some authors proposed more inclusive management practices in organisations to reduce the amount of resistance generated by leaders announcing new initiatives. In simple terms, Blanchard and Blanchard (2013:5) referred to leadership patterns that sabotage change. They emphasised that 'people who help to plan the battle seldom battle the plan', suggesting that early stage involvement of people in the design of change tends to improve trust, participation and focusing their energy on helping to make change successful.

There is a growing tendency to observe leadership as a phenomenon beyond the individual leader to acknowledge and utilise a wider range of leadership practices where leadership is "conceived of as something that happens across functions and levels. New concepts and frameworks are needed in order to embrace this more inclusive approach to leadership" (Gliddon & Rothwell, 2016; Tidd & Bessant, 2013:111).

Table 3.13 summarises the theory limitations revealed in the preceeding discussion and will inform the research design and methodology discussion in Chapter 4 as well theory development discussions in Chapter 6.

Table 3.13: Limitations of current theory

Limitations	**Reference**	**Thesis focus for technology innovation leaders**
Existing theories address only parts of research question	Henning *et al.* (2004)	Consider or propose theoretical relationships in a systemic way
Lack of theoretical advances across creativity and innovation literatures	Anderson *et al.* (2014)	Consider or propose more and more radical theoretical contributions
Multiple disciplines involved in innovation require integrative theory	Smith (2010)	Consider or propose theory that bridges academic disciplines involved in innovation
Conventional management practices seem inadequate for innovation leaders' challenges	Sen (2011) & Sutherland (2013)	Consider or propose theory beyond conventional management practice
Innovation requires theory across all established aspects of the organisation and how it is managed.	Lafley & Charan (2010)	Consider or propose theory for innovation leaders to conceive previously unimagined options for customer attraction, for staying ahead of competitors, and new ways for it to be mapped, systemised, managed, measured and improved to bring about a steady stream of innovations
Theory required for change resistence in innovation initiatives	Blanchard and Blanchard (2013)	Consider or propose change-embracing theories for innovation
Theory needed for leadership extending beyond the individual leader.	Gliddon & Rothwell, (2016); Tidd & Bessant, (2013).	Consider or propose theory for innovation to utilise leadership practices that happens across functions and levels.

3.9.2. Knowledge gap in current theory

A literature review critically explores existing literature that is relevant to the research topic to provide background information about the topic, establish the importance of the topic, develop familiarity with the topic and set the stage for further work and a scholarly conversation (NCSU, 2016). A literature review or study is conducted with the express aim of scanning secondary sources of information on the research topic and includes written sources that "...discuss, comment, debate and interpret primary sources of information" (Mouton, 2003:71).

Three limitations of the current knowledge base can be derived from the literature-based review of theory in Chapter 3:

- Innovation leadership, including technology innovation leadership appears to be a relatively new field which is only beginning to attract scholarly attention (Hill *et al.,* 2014; Swart, 2013).
- A process-based approach appears to be a common practice to identify incumbent competencies, but scholars portray different views of what an innovation process should look like. Current innovation process models suggest linear, sequential flow with confusing and conflicting leadership requirements that may have implications for technology innovation leadership competences. Scholarly evidence in favour of a particular universally-agreed technology innovation process could not be found.
- Theories considered for this study appear to be dominated by the marketing (including business), psychology, and engineering (including sciences) disciplines with no integrative theories being evident for leading technology innovation.

This chapter reviewed a range of theoretical perspectives related to the research question, including competence and competency theory, innovation theory, innovation process theory, leadership theory and innovation success perspectives. While the contributions of scholars and observers were acknowledged, none of them provided a sufficiently coherent and relevant theory that could be used for this study which is why these contributions had been converted into implications for technology innovation leaders as indicated in corresponding tables.

The introductory sentence of Section 3.6 stated that technology innovation takes place through a process and that technology innovation leaders' competencies are applied across such a process, irrespective of the number of phases or stages proposed by different process models. Process models were reviewed from which the four-stage innovation process based on a linear sequential flow could be decomposed into seven interim capability clusters, as shown in Table 3.6 and reconfigured in Section 3.9.4 to guide the further identification of technology innovation leader competencies deemed to be required for successful technology innovation. The Task partitioning theory of Von Hippel (1990) may represent requirements related to the integrative capabilities of technology innovation leaders that may become clearer when sources of knowledge on successful technology innovation processes and leader competencies are explored in response to the research question. Leadership theories referenced in innovation literature were reviewed from which it may be argued that further contributions to theory may be required in the following main areas, to answer the research question:

- Technical skills and environmental scanning at the onset of the process,
- Integration of multiple stakeholders,
- Non-sequential progression through context-specific stages; and
- Involvement of the consumer in commercialisation or technology adoption stages.

The ensuing knowledge gap is graphically presented in Figure 3.32 as clusters of theoretical contributions from which information will be drawn towards understanding the phenomenon to be studied, namely the identification of technology innovation leader competencies deemed to be required for successful technology innovation.

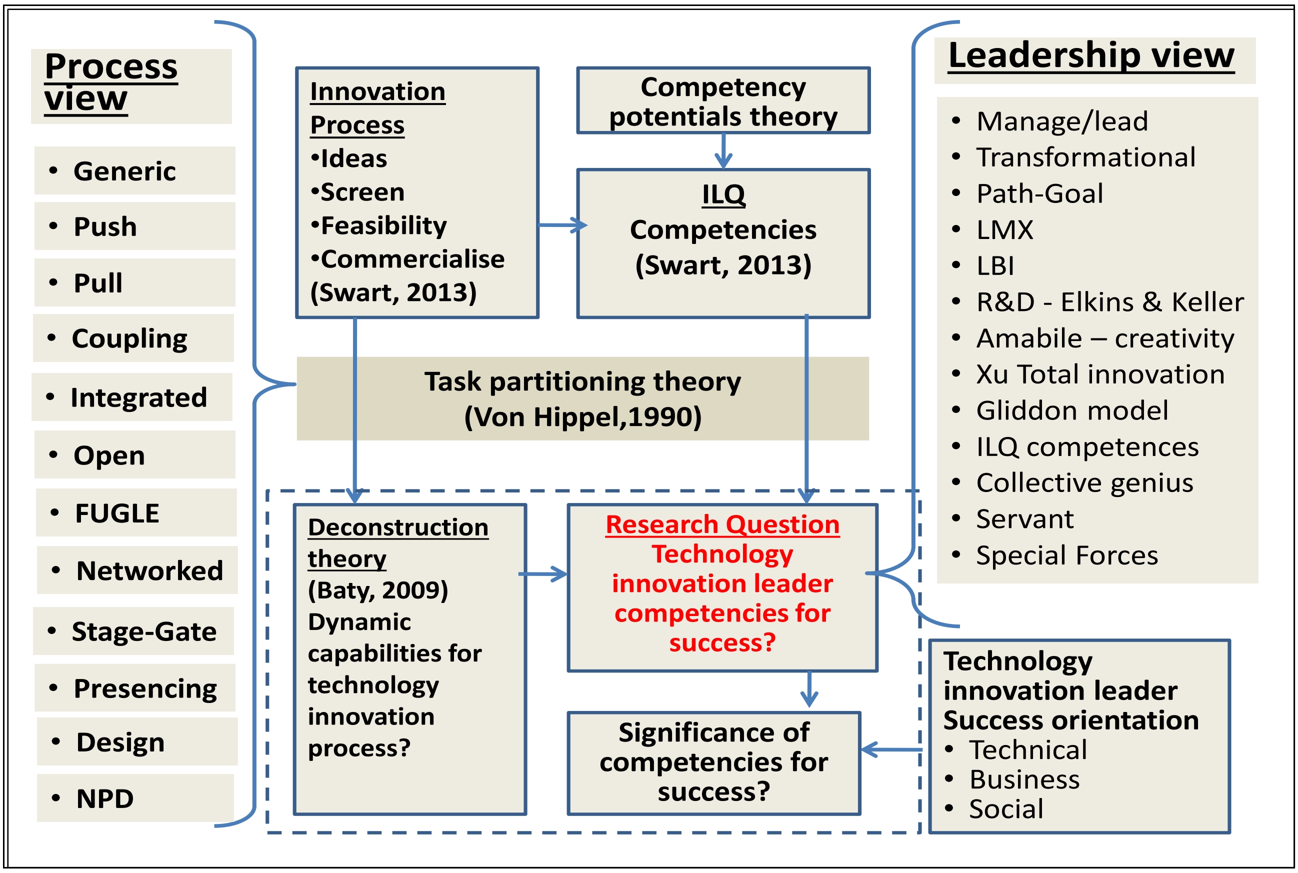


Figure 3:32: Updated conceptual model to confirm the knowledge gap

3.9.3. Towards converging views on technology innovation leader competencies

While the previous section indicated a lack of phenomenon–specific knowledge in the theoretical perspectives reviewed, the following observations represent the researcher's interpretations of some commonality in perspectives presented to guide the research design and methods selection chapter of this thesis.

Technology innovation leader competencies appear to be inextricably linked to managerial activities. In Section 3.2.8 technology innovation leader competencies were defined as sets of leadership behaviours, which are considered instrumental in facilitating and delivering technology innovation outcomes throughout the innovation process (Swart, 2013:70).

In Section 3.2.5 innovation was defined as the process of turning ideas into reality and capturing value from them – and only if we can manage the whole process, is innovation likely to be successful (Tidd & Bessant, 2013:21). Leadership theory was linked to management theory by Cole who claimed that "the crux of every management job lies in the job holder's capacity to obtain commitment from people to the objectives of the organisation", that incumbents should "exercise appropriate leadership..." and that leadership theory has only recently emerged (Cole, 2004:53).

Cole concluded that leadership should be seen as a dynamic process and that leadership is essentially about striking the right balance between people, tasks and goals in a given situation (Cole, 2004:54). Leadership at work is defined by Cole (2004:53) as "a dynamic process whereby one individual in a group is not only responsible for the group's results, but actively seeks the collaborations and commitment of all the group members in achieving group goals in a particular context...".

If the innovation process is seen as starting with an idea and concluding with its implementation (as per popular definitions such as a four-stage innovation process), then the theories presented in this chapter require additional insights to a fusion of knowledge in a way that answers the research question through a nested model framework (Malhotra, 2015). Individually the theories presented in Figure 3.32 may contribute to explain the phenomenon being studied in this thesis where innovation includes value realisation and is only likely to be successful if we can manage the whole process (Tidd & Bessant, 2013:21). Malhotra's view of using nested models in theory development is that smaller models may be subsets of other models with each smaller model being nested in the main model (Malhotra, 2015). Based on Malhotra's view, Figure 3.32 shows that the identification of technology innovation leader competencies for success may be approached as a series of five subsets of interim capability clusters that may be linked to another subset of integrative leadership that may be linked to another subset of success orientation that individually and collectively may serve as basis for competencies identification. Malhotra (2014) suggests that an integrated theoretical framework can be based on integrating theories from different research streams and be empirically tested as nested structural models as was done in this study.

Anderson *et al.* (2014:1321) referred to the "fallacy that all creativity and innovation is good and that more innovation would be better". They proposed a critical examination of the underlying assumptions implicit in the innovation maximisation. For the purposes of this study, the researcher interprets that context is created and experienced by the people involved and this study deliberately looks for evidence that might substantiate the importance of stakeholder alignment and value creation as elements in the innovation process. These considerations support the notion of interim technology innovation capability clusters to be further populated in the next phases of the study.

Despite the work of De Jong and Den Hartog (2007) and contributions from authors in sociology, psychology, economics, marketing and engineering fields, the knowledge contributions are not integrated or aggregated to the level of a coherent integrated set of competences for leaders to emulate or apply for developmental purposes (Gopalakrishnan & Damanpour, 1997).

A recent study by Swart (2013) proposed an innovation leadership questionnaire (ILQ) based on a set of innovation leader competences identified for innovation leaders in general. Technology innovation leaders were not specifically mentioned, which is the research problem being addressed by this study. Disruptive innovation is also excluded by Swart (2013), yet included in this study.

Placing the stated research problem and question in an evolutionary context, it seems that the discipline of 'management' experienced a similar evolutionary path to become an acknowledged focal area in organisational studies. The following text comes from Peter Drucker (1982:7), acknowledged by many as the father of modern management:

> *As a subject, management is multi-dimensional. It is first a discipline in its own right. It is a young discipline; modern organisations are barely a century old, and management arose with them. But while there is still a great deal we do not know, we know that management is not just common sense. It is not codified experience. It is, at least potentially, an organised body of knowledge.*

It may be argued that substituting the word 'management' in the above text with 'innovation leadership' means that today's managers are as keen to learn about innovation leadership as was the case with management in the 1970s.

Drucker (1982) described his work as a representation of what is already known and of the much larger body of ignorance.

> *[These are areas] ...in which we know that we need new knowledge, in which we can define what we need, but in which we do not as yet possess the knowledge. Yet practicing managers cannot wait. They have to manage as the problems and the needs arise.*

Drucker (1982:7) concluded by saying that management may be the most important innovation of the previous century and it should be clear from this chapter that there is a need early in the 21st century to better understand innovation leadership. Throughout this chapter references were made to the need to identify the competencies of technology innovation leaders that show a positive relationship with technology innovation success. While it may be most satisfying if a study of this nature would establish causal relationships, Babbie (2010:97) warned against expectations of finding absolutely necessary or "must be present for effect to follow" conditions.

From the work of several authors discussed in the preceding sections, no single coherent and comprehensive theoretical framework of relevance to innovation leadership has emerged yet. As a result, the contributions so far may contain elements of possible relevance to the core of this study, but still fail to meet the requirements for a technology innovation leadership competence profile based on competencies deemed to be required for successful technology innovation.

Considering the knowledge gaps revealed, and the expressed need of scholars and practitioners for evidence-based contributions to the body of knowledge on innovation leadership in general and technology innovation leadership in particular, a theoretical framework to represent a coherent and integrated set of concepts, constructs and their elements or items is proposed.

3.9.4. Interim capability clusters update

The four-stage innovation process used by Swart (2013) to identify innovation leader competencies starts with idea generation and concludes with commercialisation. Some observers suggest that innovation does not start with idea generation (Phillips, 2015). Creative thinking for a purpose is never a jumbled stream of disparate ideas – it needs focus and purpose to be effective, according to Garner (cited in Phillips, 2015). Innovation requires a distillation of ideas for ground-breaking products and services, suggesting that before idea generation, trends and strategy need to be understood, according to Andrews (cited in Phillips, 2015). Intangible capital is created in networks and is becoming more important than tangible capital. We have to adjust business to this new reality and change how we manage this (Phillips, 2015). While these concerns and process perspectives may have been accommodated in the process perspectives of Table 3.4, the interim capability clusters listed in Table 3.5 may not fully reflect these nuances yet. A more “holistic approach” to the innovation process was added for a “deconstruction of past paradigm and thought realities within the innovation decision-making process” (Steyn, 2012:420). Table 3.5 conveys a deconstruction view of process models presented and Table 3.6 conveys the conversion of the four-stage linear sequential innovation process of Swart (2013) into seven interim capability clusters. These interim capabilities were derived from a deconstruction of innovation process models, while the review of the leadership theories has introduced new perspectives that need to be accommodated in an updated version of the interim capability clusters as presented below.

The seven interim capability clusters of Table 3.6 were reworded and regrouped into six interim capability clusters in Table 3.14, to more visibly accommodate and consolidate two related concepts. Firstly, the “*Umwelt*” theory of Von Uexkull and Sebeok is rooted in an understanding of the environment and surroundings as foundations for communication and sense-making (Sebeok, 1991). Secondly, absorptive capacity (Smith, 2010; Tidd & Bessant, 2013) is the ability to detect emerging changes in the technological innovation landscape and the broader environment that may have implications on the technology innovation being pursued. Absorptive capacity includes the ability to bring such observations into the organisation, synthesise and apply in conjunction with the internal knowledge of the firm and decide whether or not to apply the learning to the organisation’s benefit. As indicated in earlier chapters of this report, the rate and magnitude of technological advancements have disrupted many industries and forced leadership to come up with new ways of survival which creates opportunities for disruptive innovation.

Kuratko *et al.* (2011:4) emphasised that the accelerated development of new technologies, rapid product obsolescence and increasing difficulty of protecting IP leave firms with a general lack of long-term control. Smith (2015:64) added that a “silo” mentality “has no place within the theory of absorptive capacity” and that “...shared knowledge and expertise is necessary for good communication”. In a technology innovation environment, there is a consistent requirement to update employees’ skills and to keep in touch with technological developments which is a leadership challenge (Osei, 2014:116). Absorptive capacity also requires those involved to learn, create new information and embrace new paradigms (Osei, 2014:116).

In light of these considerations, the four-stage process model of Swart (2013) can be extended to include and combine detection and sense-making activities early in the innovation process. Based on this extended innovation process view, the seven interim capability clusters of Table 3.6 are revised and consolidated into six interim capability clusters as discussed below and summarised in Table 3.14 to serve as updated basis for the identification of technology innovation leader competencies.

3.9.4.1. Cluster 1: Technology connectedness

To observe is to notice or watch something carefully or scrutinize (Oxford, 2009), suggesting consolidation of observation and evaluation of ignore/play options in Table 3.5 to reflect the preceding discussion to include the “Umwelt” sensing and “Absorptive Capacity” evaluation capabilities as technology connectedness. The technology innovation leader connects with the evolving technology innovation landscape for many reasons that may include gathering of knowledge on new technology alternatives and possibilities to be considered in the envisaged technology innovation.

3.9.4.2. Cluster 2: Stakeholders alignment

Table 3.5 includes an interim capability cluster that describes obtaining the support of others. Stakeholders are those persons and institutions whose support in a variety of ways may influence what would be needed or acceptable in terms of technology innovations. The technology innovation leader seeks alignment between stakeholders and the technology innovation by relating new possibilities to stakeholders’ requirements in terms of value (Oskam, 2009).

3.9.4.3. Cluster 3: Liberating mindsets

Ideating new possibilities requires those involved to apply creative thinking at different points. The technology innovation leader builds one or more teams of people to participate in the envisaged innovation through a variety of ways and diverse skills. Their backgrounds may inspire them to default in their thinking to what they know and what they are comfortable with and thus prevent them from achieving “out of the box” thinking. The technology innovation leader creates an environment where mindsets are liberated.

3.9.4.4. Cluster 4: Value creation

Ideation is converted into experimental designs, prototypes or technology demonstrators that can be assessed by stakeholders in terms of the monetary, strategic or other forms of value associated with the invention which is a signal of feasibility.

3.9.4.5. Cluster 5: Value realisation

Newly created technology is perceived as a solution which creates demand for its deployment and adoption. Scaling and deployment activities associated with the implementation and adoption of technology take place to realise value through commercialisation or other mechanisms.

3.9.4.6. Cluster 6: Integrative leadership

Leadership is not visibly covered in interim capability clusters yet and is included here to be reconsidered during the qualitative research phase. Integrative leadership means the ability of the technology innovation leader to integrate the previous clusters to bring about successful technology innovation leadership by setting the example, getting people to work together, and many other apparent contradictions in or situations of paradox, as the technology innovation evolves.

Table 3.14 provides a summary of the adjustment derived from the preceding discussion.

Table 3.14: Adjusted descriptors of interim capability clusters

Interim capability clusters	Descriptors	Rationale for adjustment
Observation of new knowledge Evaluation of ignore/play options	Technology connectedness	Purposeful ideation requires context (Phillips, 2015) "*Umwelt*" theory of Von Uexkull and Sebeok (Sebeok, 1991) Absorptive capacity (Osei, 2014; Smith, 2010; Tidd & Bessant, 2013)
Able to obtain support of people	Stakeholders alignment	Link knowledge development and exploitation (Oskam, 2009) Market orientation and receptive organisation (McAdam & McClelland, 2002)
Able to ideate new possibilities	Liberating mindsets	Innovation leader behaviour inventory implies idea generation may occur at different points in innovation (De Jong & Den Hartog, 2007).
Creating technology solutions	Value creation	Combined design thinking (Bausch *et al.,* 2014)
Implementing technology solutions	Value realisation	Implementation (DeJong & Den Hartog, 2007, McAdam & McClelland, 2002)
Integration activities across innovation process.	Integrative leadership	Processes co-exist and complement each other (SA Bio-economy strategy, 2014)

3.9.5. Theoretical framework for this study

A theoretical framework connects the researcher to existing knowledge including concepts and theories in the field of study to serve as basis for hypotheses and choice of research methods (University of Southern California, 2015). Swanson (2013) added the following nuances to what a theoretical framework may represent. A theoretical framework provides a logically-structured representation of concepts, variables and relations involved in a study with the purpose to identify what will be explored. A theoretical framework is derived from theories that aim to explain, predict, and understand phenomena and, often, to challenge and extend existing knowledge within the limits of critical bounding assumptions. A theoretical framework is a structure that can hold or support a theory of a research study. Theoretical frameworks are usually not readily found in literature and require a review of readings and research studies to find theories and analytical models of relevance to the research being conducted. These theories and models should be relevant to the research topic, and relate to the broader areas of knowledge being considered (University of Southern California, 2015).

A theoretical framework also provides an orientation to a particular study by establishing 'frames' for the work to be done. These frames may include the vocabulary used in a discipline, such as the terms defined in the introductory section, it "...anchors research in the literature" and conveys "... alignment of key concepts of the study" (Henning, Van Rensburg & Smit, 2004:25-26). At present these frames may not be aligned as reflected in the views of managers and scholars discussed. While managers call for research into the practical aspects concerned with value creation through innovation, scholars have not yet established a sufficient body of knowledge to link practice and theory. Scholars in different fields have found conversion of new knowledge into value to be the worst managed innovation phase; competencies for dealing with these innovation challenges have not yet been determined (Chiesa & Frattini, 2011).

The above requirements for a research framework were considered to conclude that the following scholarly contributions appear to offer content elements but not complete frameworks yet, which may be linked to the relative newness of scholarly interest in innovation as an emerging management discipline as discussed in previous chapters:

- De Jong & Den Hartog contributed their innovation leader behaviour inventory but acknowledge that "Neither the innovation, nor the leadership field provides a detailed overview of specific behaviours that leaders might use to stimulate innovation by individual employees" (De Jong & Den Hartog, 2007:41). Despite growing demand, innovation leadership competences are uncertain and untested (Hoque, 2013; Ashlubo; Tidd & Bessant, 2013). Innovation should be managed in new ways, based on new insights, and not driven by mere efficiencies like many managers have been trained to do (Christensen, 2004). We do not know what leadership behaviours impact positively on innovation results (Trompenaars, 2011:1).

- Special Forces framework of Dugan and Gabriel (2013) appears to offer a comprehensive framework but was derived from military practices that have not been tested in other innovation systems.
- Swart (2013) contributed the Innovation Leadership Questionnaire, but in terms of a framework it appears to be relevant in four phase linear sequential innovation processes and not the dynamic iterative process requirements of technology innovation.
- The Total innovation management framework of Xu *et al.,* (2007) appears to be an all-embracing philosophy still to be subjected to practical application in a technology innovation leader environment.
- Kaplan (2012:2-14) proposed the LEAPS-approach as a set of leadership behaviours for innovation leaders to guide them in times of great uncertainty and to drive disruptive innovation, suggesting that the leader listen, explore, act, persist and seize. None of these mentioned behaviours were found to be new or particularly relevant for technology innovation leaders in addition to what has already been covered in discussions so far.

The preceding discussions focused on both process and competencies as concepts from which the theoretical framework presented in Figure 3.33 was derived to guide the research design, the choice of research methodology and hypothesis formulation.

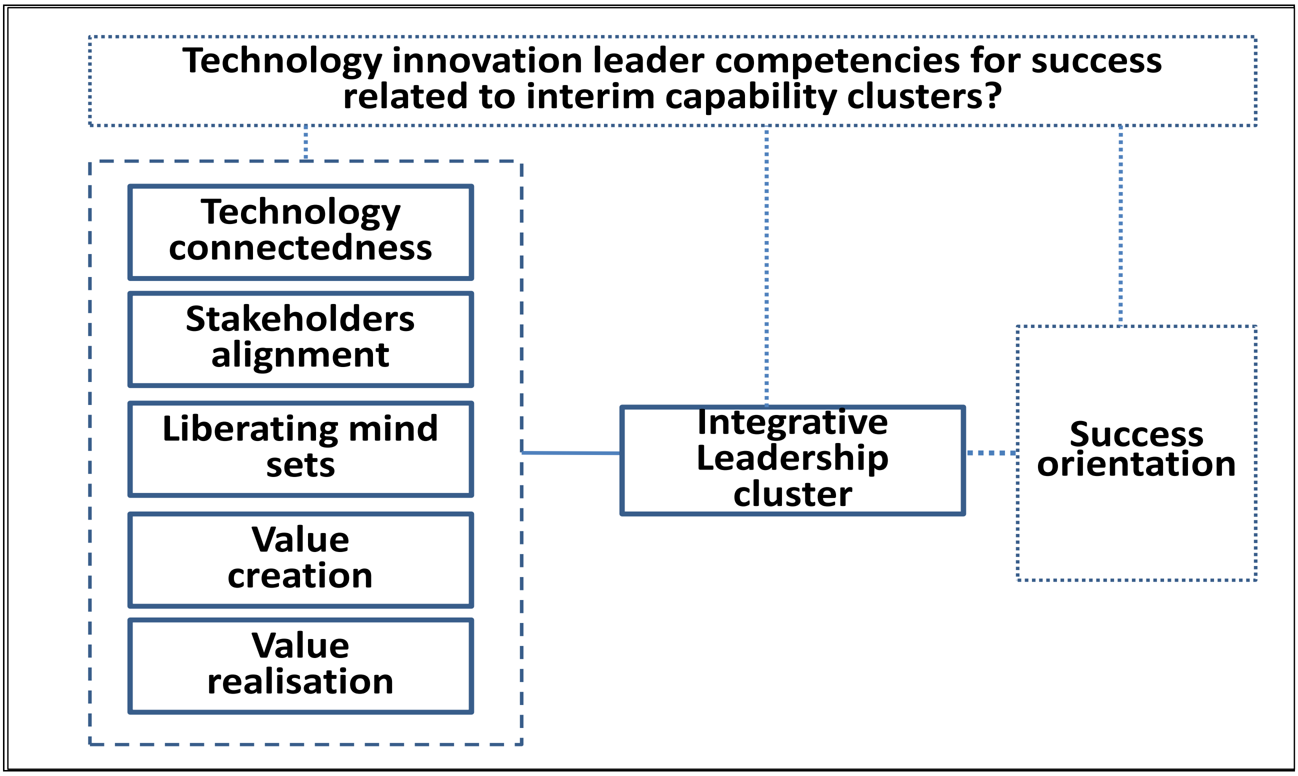


Figure 3.33: Theoretical framework for this study

A theoretical or conceptual model "frames" an inquiry by positioning the research "in the discipline or subject" in which the research takes place. It enables the researcher to theorise by making explicit "assumptions about the interconnectedness of the way things are related in the world" (Henning *et al.,* 2004:25). A theory in social sciences is of value when it fulfils the primary purpose of explaining a phenomenon so that the knowledge and understanding may be used to act in more informed and effective ways (University of Southern California, 2015).

The aim of this study is to identify technology innovation leader competencies deemed to be required for successful technology innovation. The next chapter discusses the research design and research methods for this study.

3.10. THEORY DEVELOPMENT

It is important for theory development to bridge the gulf between grand theory and research findings by considering theories that, according to Bryman and Bell (2011:9), seek to "...understand and explain a limited aspect of social life" and according to Malhotra (2015) describe a set of statements or principles devised to explain a group of facts or phenomena that can be used to make predictions about natural phenomena. While 'theory' is an explanation of observed regularities to explain a phenomenon, 'grand theory' offers a "theoretical perspective" characterised by a high level of abstraction in relation to research findings (Bryman & Bell, 2011:8).

3.11. CHAPTER CONCLUSION AND SYNTHESIS

This chapter reviewed literature related to the research questions listed in Table 3.1, namely which technology innovation leader competencies are deemed to be required for successful technology innovation, and specifically from the perspectives represented in the provisional conceptual framework, namely innovation process and leader competencies. Since both of these concepts were reviewed from an innovation context, the review started with literature pertaining to innovation, after the researcher provided clarity on important terms used through-out the study. Because competencies as a term could be confused with related or similar terms, competence and competency theory was reviewed to provide clarity that, in this study, the competencies of a technology innovation leader exclude competency potentials and related to leaders of technology innovation, as the unit of measurement used in this study.

Following the review of innovation processes, it became clear that different processes conveyed different sequences of sometimes similar activities, which resulted in the decomposition of the processes reviewed, which resulted in the identification of interim capability clusters that may be applied in different context-specific sequences and be rearranged when unfrorseen turbulence in the technology innovation landscape is ecperienced.

Leadership theories and concepts relevant to technology innovation competencies were reviewed without yielding evidence of prior studies directly related to technology innovation leader behaviours required for successful technology innovation. The interim capability clusters were then used as a framework for the identification of leader behaviours mentioned in literature as being relevant, and concluded with some potential competencies for later consideration and testing.

Success literature was reviewed to determine what it meant in the technology innovation domain from which it became clear that different people, disciplines, organisations and leaders had different views.

Sub-research question SRQ 1.1 asked the question: “Which innovation process can be considered as basis for the identification of leader competencies?” Section 3.5 did not find a particular innovation process that could be applied to the identification of technology innovation leader competencdies without modification. However, some literature suggested several shifts in emphasis and levels of integration that would have to be accommodated.

Sub-research question SRQ 1.2 asked the question: “Which alternative innovation process should be used for identification of leader competencies? This was discussed in Section 3.6 where the results confirmed the assumptions made in the provisional conceptual model for this study presented in Figure 1.6 of Chapter 1.

Sub-research question SRQ 1.3 asked the question: “Which leader competencies are required across the technology innovation process?” and this was addressed in Section 3.7.

All three sub-research questions need to be answered for the main research question to be answered. In exploring all three of them, important perspectives were found for consideration, but none could be identified as a final answer or solution and it became clear that further research would be required. The provisional conceptual model presented in Figure 1.6 in Chapter 1, and thereafter used to pose conceptual model questions in Figure 3.2, was updated in Figure 3.32 as conceptual model to confirm the knowledge gap. The theoretical framework to guide the research aimed at answering the main research question was developed and presented as Figure 3.33 to serve as input into the research design and methodology chapter discussed next.

Although the literature review did not produce conclusive definitive evidence-based answers to the research questions from the provisional conceptual model in Figure 1.6, namely technology innovation process and technology innovation leader competencies, sufficient insights were gained from the literature review to use for developing a theoretical framework for the remainder of the study, that will investigate both concepts further and then return to the literature for selective review of literature to populate emerging capability clusters, as input towards the identification of competencies.

Other reasons for conducting literature reviews include (Bryman & Bell, 2011:119):

- Reviewing main ideas and research relating to the chosen field of interest;
- Indicating new area of research needed or being conducted in the chosen field;
- Developing new or alternative views as researcher in the chosen field;
- Indicating the researcher's expertise in the chosen research domain; and
- Avoiding duplication of prior work by other scholars.

Although the reasons listed above were not explicitly articulated prior to the literature review being undertaken, the researcher has benefitted from the literature review by gaining new insights of relevance to the main study and the researcher's involvement in technology innovation.

Reviewers may observe that the sources used included peer referenced journal articles and also references to other sources of a contemporary nature, including innovation conferences, popular media and special interest groups on the Internet to complement scholarly sources (Bryman & Bell, 2011:105).

This conclusion and synthesis section of this literature review chapter has presented an overview of what was done, and the outcomes. Since the research questions discussed above have not been answered from the literature review, however, it is argued that further research would be required to answer the research questions, the format of which will be discussed in the next chapter.

CHAPTER 4

RESEARCH DESIGN AND METHODOLOGY

4.1. CHAPTER INTRODUCTION

This chapter links the preceding chapters to a research design to address the knowledge gap reported in Chapter 3. Chapter 1 discussed the complex and challenging environment in which the technology innovation leader operates. It revealed knowledge gaps in the current body of knowledge pertaining to the technology innovation leader competencies that are deemed to be required for successful technology innovation. Chapter 2 revealed the "multiple worlds" experiences of the researcher that may influence the research. Chapter 3 reviewed theoretical perspectives and concluded with a theoretical research framework to guide the research design and research methodology for this study.

Previous chapters thus provided the contextual orientations from which phenomena may be selected by the researcher for systematic and rigorous scientific enquiry in pursuit of "truthful knowledge" as valid and reliable descriptions, models and theories of the world (Mouton, 2003:138). While it is "not possible to produce scientific results that are infallible and 'absolutely' true for all times and contexts", scientists constantly strive for the most truthful and most valid results, while accepting that science remains a "self-correcting enterprise" (Mouton, 2003:138). In this chapter, the researcher adopts the tools of science in addressing the research question. This chapter also conveys the sources of evidence considered to address the research question, presents the research process, research tools and procedures to be used, as well as the steps and tasks in the research process for an "objective" (unbiased) procedure to be employed (Babbie & Mouton, 2008:74).

In light of the undertakings in Chapter 2, where the background and potential bias of the researcher was discussed, the research discussion in this chapter is guided by the following good research practices (Babbie & Mouton, 2008; Bryman & Bell, 2011):

- A clear, logical structure for undertaking the research is provided;
- It is evident from the writing that the main research topic has been understood;
- Main ideas are supported and developed;
- Titles, headings, subheadings and paragraphs are effectively used to help the reader grasp the organisation of the research approach, its execution and results;
- Coherent, clear connections are made between sentences, paragraphs and sections;
- The introduction is well-integrated; and
- Graphics/diagrams are well-integrated in the text.

Figure 4.1 provides a schematic map of elements and key messages addressed in this chapter.

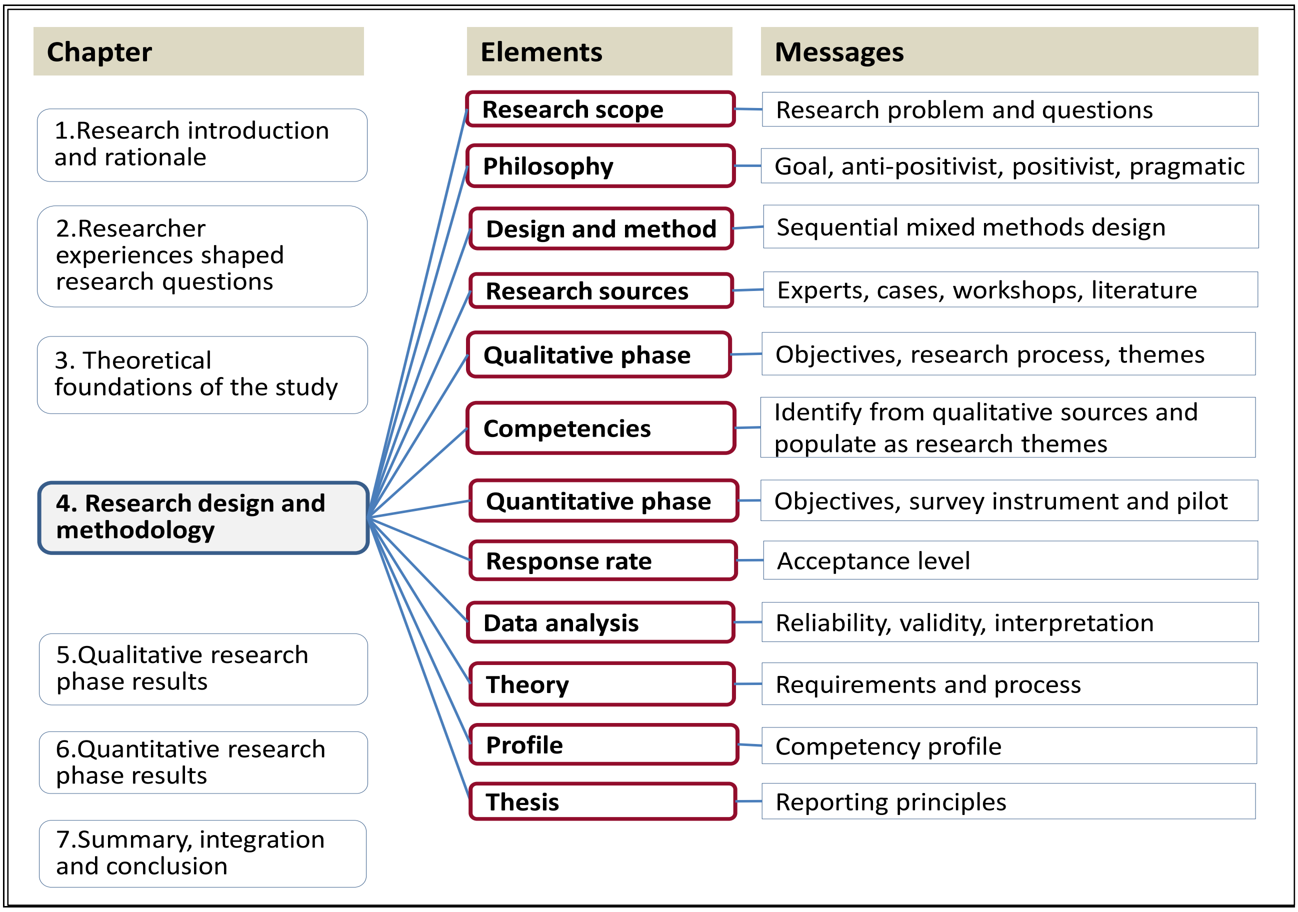


Figure 4.1: Thesis map of Chapter 4

4.2. RESEARCH PROBLEM AND QUESTIONS

Despite the increasing interest and growing significance of innovation, and exponential increase in scholarly material on innovation and theories reported so far, it is still not clear what competencies are deemed to be required by technology innovation leaders for successful technology innovation. In this study, the phrase "deemed to be required" is used to refer to the opinions of the research participants, based on their experience of successful technology innovation. They had to give their opinions on the significance of leader competencies in achieving successful technology innovation. The leader competencies had been identified from their inputs.

4.2.1. Research question related to the provisional conceptual model

The stated research problem may be expressed as a research question or hypothesis (Babby & Mouton, 2008:72), which for this study reads as: "What are the technology innovation leader competencies deemed to be required for successful technology innovation?" The main reseach question was supplemented by sub-research question listed in Table 4.1.

The literature review presented in Chapter 3 concluded that the main research question had not been adequately answered from the current body of knowledge, and that the conceptual model as presented in Figure 1.6 and updated in Figure 3.32, may be used to proceed with further scientific enquiry as guided by the research questions.

In line with the provisional conceptual model presented in Figure 1.6, the main variables to be explored remained the same as for the literature review, which did not provide adequate answers to the innovation process and leader competencies research questions.

The theoretical framework presented in Figure 3.33 retained the interim capability clusters presented in the provisional conceptual model as well as their proposed relationships, to be confirmed as research themes for the qualitative research phase.

4.2.2. Research sub-questions

In addition to the stated research question, the following sub-questions have been identified from those raised in Chapter 2 and from further researcher reflection on the theoretical foundations in Chapter 3:

- "If the answer to the research question has not been adequately answered in literature, who could be viewed as competent, to assist in finding possible answers?"
- "If those with possible answers are willing to share their knowledge, how should this be captured?"
- "Would the provided answers be sufficient to establish the relative significance of identified leader competencies and relationships between these?"

An infinite range of questions may be added with different levels of relevance to this study. The main research question thus remains the focus of this study, supplemented by the research sub-questions posed in Table 3.1 to guide the literature review, and extended in Table 4.1 to inform the research design and methodology discussion.

Table 4.1: Research sub-questions

Research sub-questions	Reference section
SRQ 1.1 Which innovation processes can be considered as basis for the identification of leader competencies?	Section 3.5
SRQ 1.2 Which innovation process should be used for identification of leader competencies?	Section 3.6
SRQ 1.3 Which leader competencies are required across the technology innovation process?	Section 3.7
SRQ 1.4 What are the actual technology innovation processes used by successful technology innovation leaders?	Section 4.6 to Section 4.8
SRQ 1.5 What are the technology innovation leader competencies for success?	Section 4.6 to Section 4.8; Section 5.5
SRQ 1.6 What leader behaviours underpin identified leader competencies?	Section 4.6 to Section 4.8; Section 5.4
SRQ 1.7 How do technology innovation processes and technology innovation leader competencies interact in a hypothesised model?	Section 4.11; Section 5.5; Figure 4.11
SRQ 1.8 What are the statistical relationships between and within constructs in the hypothetical model?	Section 6.4; Figure 6.5; Figure 6.6
SRQ 1.9 How could the findings and results be used in the development of a theory of integrative innovation leadership?	Section 4.11; Section 6.4.7.5; Section 7.3
SRQ 1.10 How can the findings and results of the study be presented as a competency profile, as suggested in the title of the study?	Section 7.3.5

4.2.3. Innovation as a science

When Christensen (2002:1) referred to innovation as “a new science of success,” it may have been interpreted as a signal that innovation is advancing towards the ultimate goal of science referred to as the “*epistemic imperative* or moral commitment by scientists” to “the search for truth and knowledge” (Mouton, 2003:239). While progress has been made in the identification of important variables that affect the probability of success in innovation, Christensen (2002:4) claimed that the observed probabilities of success are low and that innovations fail within organisations that are “incapable of succeeding”.

For Christensen (2002), innovation as management discipline was still evolving and would require a better understanding of cause and effect relations to make innovation become more predictable with less randomness. Such paradigm shifts coincide with scientific revolutions when new observations no longer fit “primitive resemblance criteria”, when previously acquired boundaries become excessively narrow, and new observations demand some adjustment in such boundaries (Kuhn, 2012:21). Sharing of successful practices by practicing experts can serve cognitive functions commonly attributed to boundaries and rules. When this happens, knowledge develops differently from the way it does when governed by rules and such paradigms become essential for continued research (Kuhn, 2012:22).

Based on Thomas Kuhn's (Kuhn, 2012) work on the structure of scientific revolutions, various phases of scientific renewal can be distinguished, starting with normal science. Normal science is (i) when those involved in the field, such as management studies, have an established base of reference materials and established practices for puzzle solving, within a particular paradigm. (ii) Anomalies occur and when these grow in size and magnitude, (iii) a crisis appears followed by (iv) a change in worldview and resulting in (v) revolution, which becomes (vi) the new paradigm and next wave of normal science.

Figure 4.2 conveys these phases in a cyclical format and suggests "revolution" as the stage in which innovation, as emerging management discipline, finds itself.

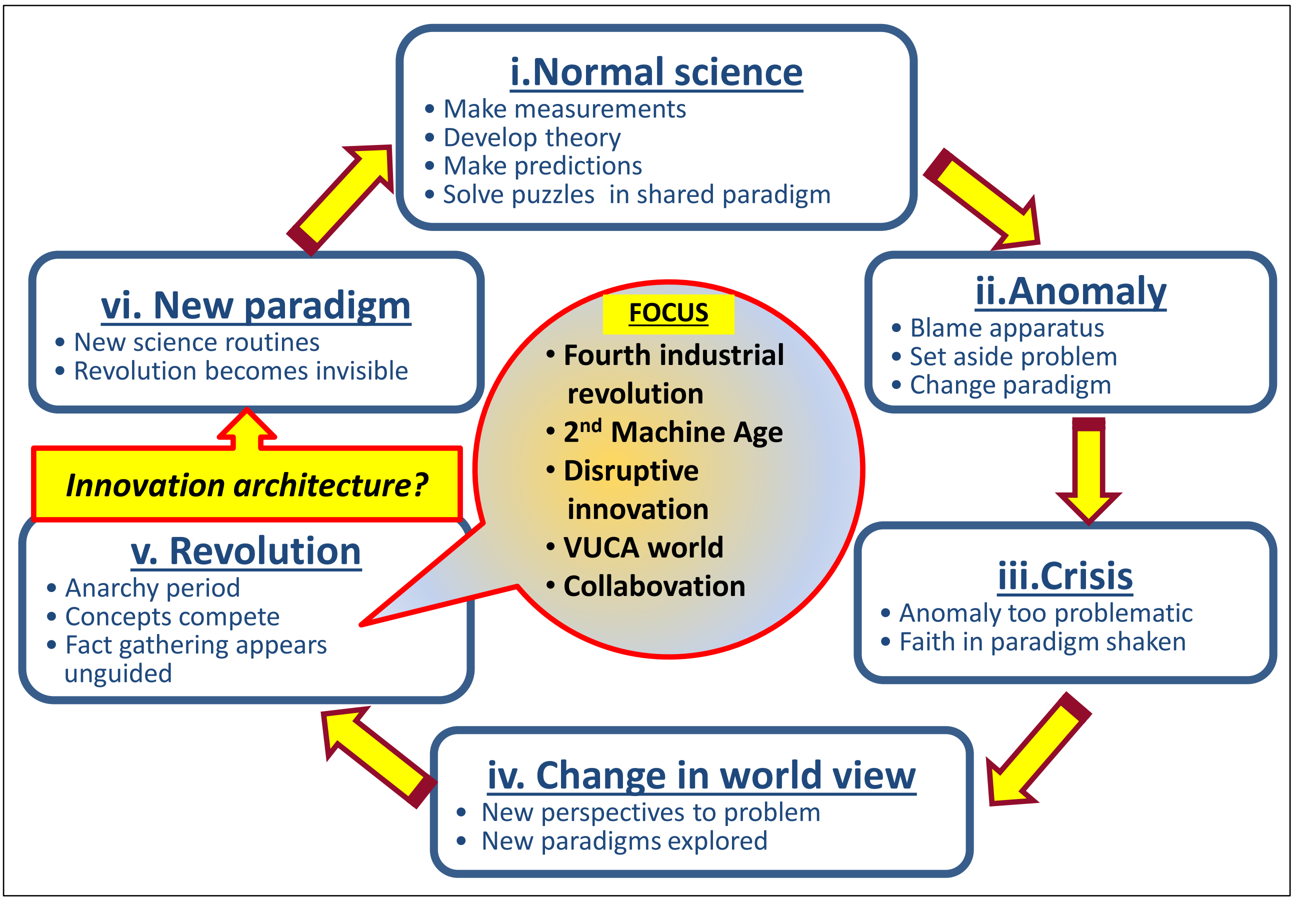


Figure 4.2: The structure of scientific revolutions: Innovation

Source: Adapted from Kuhn, 1962.

From previous narrow views, such as innovation being the same as new product development, the innovation worldview has since shifted. Today, innovation scholars would regard innovation as creative thinking resulting in value manifestations beyond any narrow definition, to also include process, service, open and social innovation, as well as technology innovation (Rosenfeld *et al.,* 2011, Tidd & Bessant, 2013).

During the revolution phase of Kuhn (2012), concepts compete amidst unguided fact-finding until some convergence takes place. Management practices need to be renewed to deal with

"...a highly tumultuous wave – a cycle of disruptions" and "...each disruption brings rebirthing... transforming mindsets, structures, systems and processes," "...we need ways to "navigate through partial lenses onto situations that are held as an absolute truth" to find ways of dealing with "multiple truths" before we will understand what a "co-created viable solution" might look like (Pampallis, 2016:1).

The preceding discussion suggests that innovation is in the revolution phase of Kuhn, with signs of it entering a new paradigm towards which this study aims to contribute. If science is viewed as "finding out", the researcher has to specify as clearly as possible what has to be found out and select the best way to do it (Babbie & Mouton, 2008:72). These two aspects are addressed in the following section by reflecting on the research philosophy, goals and logic of this study.

4.2.4. Research contribution

According to Volschenk (2016: 86), theoretical contributions involve findings that change, challenge, or fundamentally advance our understanding of phenoma and make us think differently to what past research has suggested. A supplementary view is that the contribution of research is to replace intuition with informed judgement (Parker, 1991).

Money (cited in Volschenk, 2016:87) proposed three research contribution levels, namely: (i) context; (ii) method; and (iii) theory. *Context* involves the framing of research contributions in terms of Who, Where and When (Volschenck, 2016:89), which falls outside the scope of this study. *Method* contributions can be in the form of applying a new methodology in an existing field and context (Volschenk, 2016:90) which, in this study, manifested in the triangulation of research sources across innovation and leadership theories and incorporating perspectives from different disciplines. *Theory* contributions involve the linking of research outcomes to theory by extending or refining existing theory or generating new theory (Volschenk, 2016:88, 89).

In light of these positioning perspectives and the knowledge gap revealed in Chapter 3, this study focused on generating new theory by identifying new constructs, generating novel conceptual models and developing theory by drawing on existing bodies of knowledge (Volschenk, 2016:89).

As discussed in Chapter 3, theory development should seek to understand and explain a limited aspect of social life (Bryman & Bell, 2011:9), and describe a set of statements or principles devised to explain a group of facts or phenomena that can be used to make predictions about natural phenomena (Malhotra, 2015). In this study, the research outcomes include the following contributions to the formalised body of knowledge on leader competencies deemed to be required for successful technology innovation:

- Identifying technology innovation leader competencies deemed to be required for successful technology innovation;
- Linking relationships between identified technology innovation leader competencies; and
- Creating a conceptual competency profile.

4.3. RESEARCH PHILOSOPHY

Philosophy can be described as the study of the fundamental nature of knowledge, reality and existence, while a set or system of beliefs may also be implied (Oxford, 2009). Research is the study of materials and sources in order to establish facts and reach new conclusions (Oxford, 2009).

To address the research problem of a study, the researcher therefore needs to declare the way in which data about a phenomenon should be gathered, analysed and used by the researcher to be appropriate for the purpose and focus of the research (Quinlan, 2011:95).

Justification for selecting particular worldviews should coincide with a dominant perspective on the social world (Quinlan, 2011:94). The choice and use of particular research methodologies and data collection methods relate to the assumptions about reality that the researcher brings to the research work and theoretical perspective (Quinlan, 2011:95).

Research from a positivistic worldview aims to uncover general laws of relationships that apply to all people, all of the time and is associated with quantitative research (Welman, Kruger & Mitchell, 2012: 6). Anti-positivists are opposed to upholding the natural-scientific method as the norm in human behavioural research and claim that when human experience is the object of research, such human experience cannot be separated from the person experiencing it (Welman *et al.,* 2012: 6). Anti-positivists favour a qualitative research approach that allows the researcher to understand social and psychological phenomena from the perspectives of the people involved (Welman *et al.,* 2012: 6,192).

The justification for selecting particular worldviews for this study is determined by the overall goal and objectives of the study in the next section (Quinlan, 2011:94).

4.3.1. Overall research goal and objectives

In light of the research problem and question posed in Section 4.2, the formulation of an overall research goal and objectives would influence the worldview underpinning the research and focus of scientific enquiry and selection of research methods and tools for this study (Babbie & Mouton, 2008; Quinlan, 2011). The central research question guiding the focus of this study is thus converted into the following goal and objectives.

Table 4.2: Research objectives underpinning the overall research goal

Research objectives (RO)	Research activities	Related discussions
RO 1 To identify technology innovation leader competencies	Confirm interim capability clusters as research themes to identify competencies from research sources as inputs for constructs	Chapter 4 and 5
RO 2 To assess the significance of identified technology innovation leader competencies	Develop and apply a measurement instrument to assess significance	Chapter 4 and 6
RO 3 To establish relationships between assessed technology innovation leader competencies	Hypothesise relationships between constructs as statistical indicators	Chapters 6 and 7
RO4 To maintain good research practices	Demonstrate good research practices as identified in Section 4.1 in response to countering researcher bias as discussed in Chapter 2	Chapters 4, 5, 6 and 7

The overall research goal is to contribute to addressing the identified knowledge gap by identifying the technology innovation leader competencies deemed to be required for successful technology innovation. The overall research goal can be cascaded into more specific research objectives linked to further discussions as indicated in Table 4.2.

In order to achieve the research goal and objectives, the researcher accepts that a study of this nature has to limit its scope, while maintaining adequate levels of research validity and reliability, as anchored in the worldviews adopted below and discussions to follow. Research validity refers to how logical, truthful, robust, sound, reasonable and useful the research in question is (Quinlan, 2011:42). Reliability is the degree to which the research can be repeated, while obtaining consistent results (Quinlan, 2011:42).

4.3.2. Rationale for adopting an anti-positivist worldview

Based on the classification of research designs by Babbie and Mouton (2008) and the research question, this study can be described as exploratory in nature since the purpose of research is "to explore a topic or to provide a basic familiarity with a subject which is relatively new" to reveal "insight and comprehension rather than the collection of detailed, accurate, and replicable data" (Babbie & Mouton, 2008:80). Exploratory studies frequently involve the use of in-depth interviews, case study analysis and the use of informants that require an open and flexible research strategy (Babbie & Mouton, 2008). Exploratory research is conducted when few or no previous studies exist and the aim is to identify patterns, hypotheses or ideas that can be tested or form the basis for further research, to provide alternative explanations or to confirm the exploratory results (Babbie & Mouton, 2008). Research techniques typically include observation, case studies, and reviews of previous related studies and data (University of Bradford, 2016). While exploratory studies are seen as essential when a researcher is breaking new ground and can almost always yield new insights into a research topic, "...they seldom provide satisfactory answers to research questions, though they can hint at the answers and can give insights into the research methods that could provide definitive answers" (Babbie & Mouton, 2008:80).

In scientific descriptive research, the researcher observes and then describes what was observed using careful and deliberate observation and scientific descriptions that are "…typically more accurate and precise than casual ones" (Babbie & Mouton, 2008:80). Descriptive research may include conceptual analysis (development of typologies and taxonomies), historical analysis of narrative descriptions and "...the retrospective reconstruction of small numbers of cases (case studies)" (Babbie & Mouton, 2008:81).

Bryman and Bell (2011:22) described constructionism as "an ontological position which asserts that social phenomena and their meanings are continually being accomplished by social actors, which implies that social phenomena and categories are produced through social interaction and in a constant state of revision". In traditional research interviews, language is a way of revealing what interviewees think about a topic or their behaviour and reasons for such behaviour (Bryman & Bell, 2011:527).

Discourse analysis (DA) is "an approach to language that can be applied to forms of communication other than talk" and can be "...applied to other types of text, such as company mission statements, websites, or email messages" (Bryman & Bell, 2011:525) to constitute "a particular view of social reality" (Bryman & Bell, 2011: 527). To follow a DA-based communication approach to link the exploratory and descriptive components of this study, may address possible researcher bias, as discussed in Chapter 2, yet it could be problematic considering the creative aspects involved in technology innovation causing discourse analysts to "resist the idea of codification of their practices" and prefer to see their style of research as an "analytic mentality" or "a craft skill" rather than following a recipe (Bryman & Bell, 2011:526).

Considering the discussion above, the researcher justified and adopted a research approach that aimed to meet the following criteria:

- An open and flexible research strategy which may lead to insight and comprehension as required for the stated exploratory research (Babbie & Mouton, 2008).
- The use of multiple sources of research information for descriptive purposes (Babbie & Mouton, 2008).
- Once primary data revealed observable patterns in analysis, secondary research data in the form of literature and other triangulation sources were adopted (University of Bradford, 2016).
- Constructionsism featured in expert interviews where the researcher paraphrased and raised questions to clarify what interviewees were saying (Bryman & Bell, 2011:22).

- Discourse analysis was not actively pursued in this study but served to sensitise the researcher to notice signals other than interviewee responses that could be used to extrapolate from interviewee answers, and contribute to a better understanding of expressed views (Bryman & Bell, 2011).

4.3.3. Rationale for adopting a positivistic worldview

Quinlan (2011:13) described epistemology as "the theory of knowledge; it is the branch of philosophy concerned with what knowledge is and how it is created". In this study, an anti-positivistic worldview was applied to understand the research phenomenon before adopting a positivistic approach for assessment of the significance of identified constructs, as further discussed in the respective sections.

Ontology is known as the study of the nature of reality (Quinlan, 2011) and different schools of thought hold different views on the nature of reality. Positivists approach reality as being singular and objective, interpretists view reality as multiple and subjective, while social constructionists deem reality to be socially constructed, in other words phenomena developed within social contexts. This study argues for reality as determined by the practitioners participating in the study. The epistemological and ontological orientations of this study are further discussed in the mixed-methods section to follow.

4.3.4. Rationale for adopting a pragmatic worldview

While scientific credibility is important in management-relevant science, the pursuit of academic credibility alone can compromise the salience and legitimacy of information in the eyes of decision-makers. From a *pragmatic* perspective therefore, knowledge contributions should be both scientifically and managerially relevant and timely (Cook *et al.,* 2013). Pragmatism draws on "what works" perspectives using diverse approaches, giving primacy to the importance of the research problem and question, and valuing both objective and subjective knowledge. Mixed-methods research should use a methodology and philosophy that aim to fit together the insights provided by qualitative and quantitative research into a workable solution. Pragmatism also proposes that research approaches be mixed in ways that offer the best opportunities to answer important research questions (Johnson & Onwuegbuzie, 2004). Creswell (2003) introduced the notion of pragmatism in research designs and proposed pragmatism as a knowledge claim position in which practical considerations are considered, including consequences of actions, problem-centred and real-world practice oriented.

Pragmatism is reflected throughout this study by the way in which researcher observations and theoretical inputs are interpreted in practical terms to be useful in the identification of technology innovation leader competencies in line with the expressed research goal.

4.3.5. Research process logic

Research is required to address the research question through a systematic enquiry aimed at producing new and generalisable knowledge, new meaning or a deeper understanding of meaning (Stellenbosch University, 2014). This systematic enquiry requires a research design which includes a strategy by specifying what needs to be observed and determining the best way to do it (Babbie & Mouton, 2001:72). Research design for social sciences should acknowledge the critical linkages between the research question, research analysis, research data and research answer (Bergman, 2013). Figure 4.3 illustrates a scientific enquiry process to conduct research informed by these requirements (Babbie & Mouton, 2008:72-73).

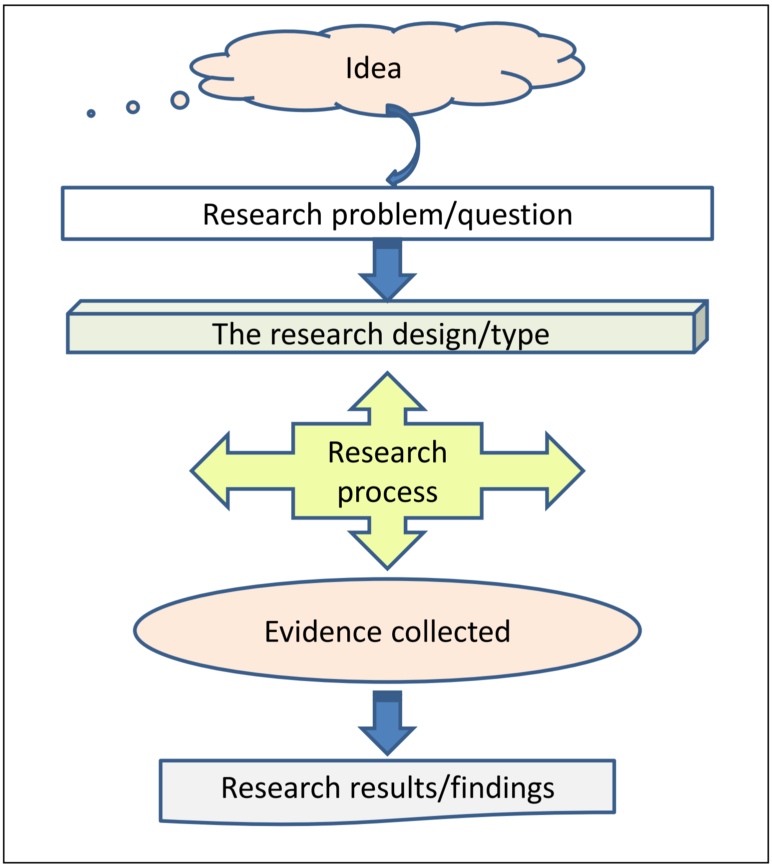


Figure 4.3: The logic of the research process

Source: Babbie and Mouton, 2008:72-73.

The process elements illustrated in Figure 4.3 as they apply to this study can be briefly summarised as follows:

- The research problem is: “We do not know which leadership competencies impact positively on innovation”, as discussed in Chapter 1 and Chapter 3.
- The research question is: “What are the competencies of technology innovation leaders that are deemed to be required for successful technology innovation?” as discussed in Chapter 3 and addressed in the next chapters within knowledge-intensive organisations in South Africa.

- The research design is a plan or blueprint of how research is conducted; it indicates the type of study required to provide acceptable answers to the above-mentioned research problem or question (Mouton, 2003), as discussed in Chapter 4.
- The research type is a mixed-method research study, as is discussed further below. The information needed to answer the research question was obtained through both qualitative research to understand the phenomenon being studied (non-positivitic) and quantitative research (positivistic) to empirically establish what the concept of successful technology innovation entails; whether the identified technology innovation competencies are correctly operationalised, and how they are conceptually related within an exploratory technology innovation model.
- The process required to answer the research question spans across two phases, i.e. qualitative and quantitative. During the *qualitative* phase, expert opinions were solicited and blended with research data from other sources with respect to two areas, namely the technology innovation process and the technology innovation leadership competencies that are deemed to be required for successful technology innovation. These results were integrated in a survey questionnaire utilised in the *quantitative* phase and completed by technology innovation leaders, in which they expressed their opinions on the significance of each of the identified competences in relation to successful technology innovation.
- Evidence was collected in the form of research findings from both research phases. All data were safeguarded in line with the ethics approvals granted.

The research process of this study thus allows the research question to be answered in two phases, starting with an *interpretive* exploratory qualitative phase and followed by a *positivistic* quantitative survey-based phase (Babbie & Mouton, 2008).

4.4. RESEARCH DESIGN LINKED TO METHODOLOGY

A research design serves as a framework for collecting and analysing data and the choice of research design reflects the priority given by the researcher to a range of dimensions of the research process, including the following (Bryman & Bell, 2011:40):

- Understanding behaviour and the meaning of that behaviour in its specific social context, and having a temporal appreciation of social phenomena and their interconnections.
- Expressing causal connections between variables;
- Generalising to larger groups of individuals than those forming part of the investigation.

A research design is also a plan or blueprint of how research is conducted, and the type of study required to provide acceptable answers to the research problem or question such as qualitative, quantitative or mixed (Mouton, 2003:49-53,107).

Researchers tend to confuse research design and research methodology "but these are two very different dimensions of research" (Babbie & Mouton, 2008:74). The differences are summarised in Table 4.3 and are addressed in the qualitative and quantitaive research sections to follow.

Table 4.3: Differences between research design and research methodology

	Research design	**Research methodology**
Focus:	Kind of study. Kind of results aimed for. Research logic: the kind of evidence required to address the research question adequately.	Research process. Research tools and procedures to be used. Individual (not linear) steps in the research process and the most "objective" (unbiased) procedure to be employed.
Departure:	Research problem or question.	Specific tasks (data collection or sampling).

Source: Adapted from Babbie & Mouton, 2008:74.

"Paradigm wars" is the description given to the choice of research designs by Cameron (2009:140) who views 'purists' as those who resist any mix of research designs and methods, and the 'pragmatists' who argue against a false dichotomy between qualitative and quantitative research paradigms and favour an efficient combination of both approaches A mixed-methods study considers both qualitative and quantitative data and their integration in the same study (Creswell, Plano Clark, Gutmann & Hanson, 2003).

The explicit selection of a research design is regarded as one of the components that make up the doctorateness of research (Trafford & Leshem, 2009), and the research objectives in Table 4.2 informed the selection for this study. The exploratory nature of this study requires both qualitative and quantitative research for which a mixed-methods study is recommended and discussed below (Meissner, 2010). The sequence of the flow is accommodated in a sequential mixed-model research design in which qualitative research is followed by quantitative research and data from the qualitative phase is connected to the quantitative research (Cameron, 2009:145). A sequential exploratory design starts qualitatively and may require the qualitative strand to have a higher priority in the research design to provide inputs for the quantitative strand, the integration of the two strands requires interpretation, and theoretical perspective may be present, as was the case in this study (Creswell & Plano Clark, 2011).

4.4.1. Mixed-methods research

The scientific enquiry design affects the selection of research methodology which Babbie and Mouton (2008:75) described as the tools and procedures to be used in the research process. The point of departure is the specific task at hand such as data collection or sampling, and the research methodology which focuses on the individual steps in the research process and the most "objective" (unbiased) procedures to be employed. The preceding research design section conveyed the rationale for adopting a blend of worldviews that would manifest in both qualitative and quantitative evidence as also implied in Table 4.4.

Table 4.4: Differences between qualitative and quantitative research

	Qualitative	Quantitative
Orientation	Inductive; theory generation	Deductive, theory testing
Epistemological orientation	Interpretivism	Natural science, positivism
Ontological orientation	Constructionism	Objectivism

Source: Adapted from Bryman and Bell, 2011:27.

Meissner (2010:5) sees the strength of qualitative research as its suitability for inductive or theory-development driven research that helps the researcher to understand processes, especially those emerging over time, based on information about context and voices of participants. Quantitative research is described as ideal for measuring pervasiveness of phenomena and patterns of association, including inferences of causality. Meissner (2010:5) suggested that a mixed-method approach be used when the criteria in Table 4.5 are met, as is the case in this study.

Table 4.5: Mixed-method research criteria of Meissner

1	Focusing on research questions that call for real-life contextual understandings, multi-level perspectives, and cultural influences
2	Employing rigorous quantitative research assessing magnitude and frequency of constructs and rigorous qualitative research exploring the meaning and understanding of constructs
3	Utilising multiple methods, such as intervention trials and in-depth interviews
4	Intentionally integrating or combining these methods to draw on the strengths of each
5	Framing the investigation within philosophical and theoretical positions

Source: Meissner, 2010:5.

According to Meissner (2010), mixed-method research also represents an opportunity to transform paradigm tensions into new knowledge through a dialectical discovery, as may be relevant for this study, in light of Kuhn's model presented in Figure 4.2. A mixed-method research approach was used in a similar study of innovation leader behaviours by De Jong and Den Hartog (2007:46) who "combined in-depth interviews and literature research to develop the inventory of leader behaviours". They described an in-depth interview as a qualitative research technique that is particularly useful for exploration purposes, such as developing propositions on a particular subject and deemed it suitable as research technique for relatively-unexplored subjects. They regarded the use of literature as important to complement the results of an exploratory study, which is why they used information from the body of knowledge for their theorising on leadership, as well as idea generation and application behaviour (De Jong & Den Hartog, 2007:46). De Jong and Den Hartog (2007:58) acknowledged that the inclusion of quantitative research through a large-scale survey, would have added usefull insights, which is why the researcher combined qualitative and quantitative research in this study.

Figure 4.4 conveys a broad illustration of how the research questions relate to the research problem and how the qualitative and quantitative research activities contribute towards knowledge to address the research problem.

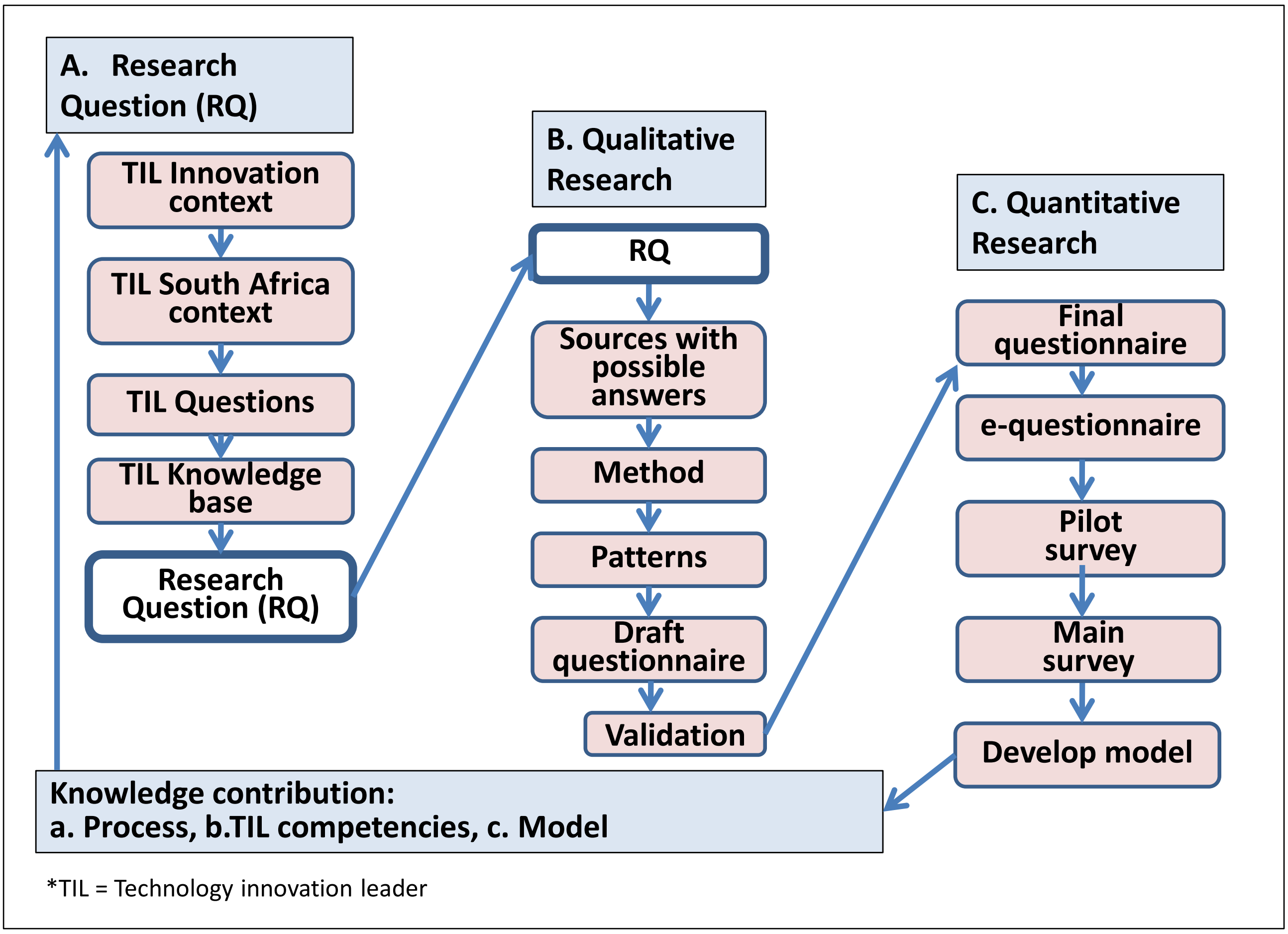


Figure 4.4: Qualitative and quantitative contributions to answering the research question

4.4.2. Research process as two phases with milestones

Based on mixed-methods approaches of Meissner (2010) and Creswell *et al*. (2010), the mixed-method research process of this study is illustrated in Figure 4.5. This figure indicates the two major phases of the research, as well as their itemised activities and milestones, followed by discussions on each phase in their respective sections and chapters.

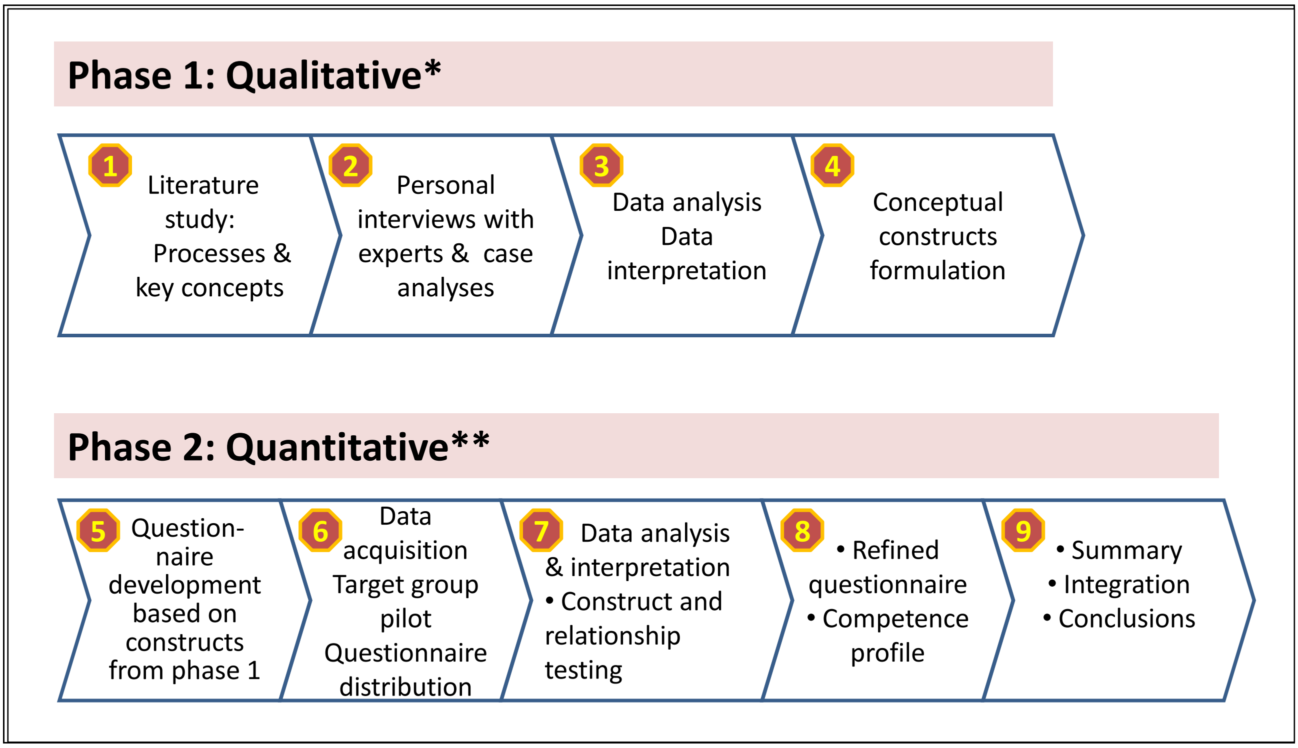


Figure 4.5: Mixed-method research process in two phases

4.4.2.1. Phase 1: Qualitative research

Bryman and Bell (2011:13) proposed an iterative approach to qualitative research that combines both deduction and induction. In *deductive* qualitative research the application of theory leads to observations and findings, while *inductive* study reverses this connection to start with observations and findings from which theory emerges through iterative weaving back and forth between data and theory (Bryman & Bell, 2011:13). As an iterative approach, this is similar to that of one of the greatest inventors of all times who said: “First I shall do some experiments before I proceed farther, because my intention is to cite experience first and then with reasoning show why such experience is bound to operate in such a way” – Leonardo da Vinci (Capra, 2007). These considerations allow for the development of a theoretical perspective that is largely uncontaminated by existing theoretical approaches in order to meet the requirements of this study (Babbie & Mouton, 2008:74).

4.4.2.2. Phase 2: Quantitative research

In contrast with the qualitative research discussed above, quantitative research can be construed as a research strategy that emphasises quantification in the collection and analysis of data. Quantitative research entails a deep inductive approach to the relationship between theory and research, in which the testing of theory is accentuated, the natural scientific model and positivism are acknowledged and social reality is viewed as an external, objective reality (Bryman & Bell, 2011:27).

4.5. RESEARCH INFORMATION SOURCES

Despite exponential growth in scholarly contributions to the field of innovation, as indicated earlier in Figure 1.3, a knowledge gap was identified which this study aims to address by using different sources of research information as shown in Figure 4.6.

4.5.1. Secondary research information from literature

Secondary research uses data that other researchers have collected or data that other organisations have collected "in the course of their business" (Bryman & Bell, 2011:312). While the use of such data may render cost or time-related advantages, the researcher may not assume its relevance and secondary data may have to be combined with primary data (Bryman & Bell, 2011). Secondary data sources considered in this study include literature, social media, and materials available from professional bodies and knowledge communities.

Authors of popular literature have been criticised for using quotations from biographical works to reify the author "...as a mouthpiece for an over-simplified, consistent collective identity". This is a model which has been criticised in the social sciences and has been rejected by many academic authors (Taylor, 2012:390). Bryman and Bell (2011:595) added a tendency of authors to use quotations from interviews "...with little sense of the prevalence of the phenomenon they are supposed to exemplify".

Available literature is used throughout this study for both secondary and primary research purposes. A directed review of innovation literature is supplemented with related leadership, marketing, psychology and engineering literature sourced from electronic databases, including Science Direct, EBSCOhost, Emerald, ProQuest and Wiley InterScience journals and databases. Books, journal publications, conference papers, web-based information were considered. Chapter 3 discussed the use of secondary sources to formulate six interim capability clusters to serve as basis for the identification of technology innovation leader competencies deemed to be required for successful technology innovation.

Speculative and intuitive contributions found in popular management literature, blogs and conversation forums may not have been subjected to the rigour of scientific research protocols and were only considered as research input when scholarly sources were not readily accessible or unavailable. Popular literature and social media used by innovation practitioners were also considered to supplement scholarly perspectives relating to technology innovation leader competencies to address the following literature review goals:

- Obtain an overall perspective on what has been covered in terms of theory, context and clarification of terminology;
- Confirm the need for this study;
- Refine the focus and envisaged contribution of this study;
- Verify initial assumptions;

- Learn from the approaches, methods and findings of other authors;
- Identify dominant perspectives on innovation processes and underpinning competencies.

The multi-disciplinary nature of this study necessitates the inclusion of scholarly perspectives from several disciplines (CSIR, 2010). Through search engines, a total of 155 potential journal titles were identified as being of possible relevance to this study, but only 22 were found to be published in fields that can be associated with the research question of this study. Some of these journals appear to be inactive, closed, or specialised for specific communities through paid subscription not accessible through the university library. A ranking of leading technology and innovation management specialty journals by Linton and Thongpapanl (2004) contained a list of their top-50 journals in technology management based on their citation analysis. In both cases, the accessible journals were scanned for content that the researcher deemed to be directly relevant to the title and research question of this study.

4.5.2. Primary research sources

Primary research was conducted by the researcher to address the research question (Babbie & Mouton, 2008). Primary research information is added to what already exists in some form or another (such as statistics and political speeches) and the researcher has to gather new information or data during the research. Examples of textual information or qualitative data include "documents, transcripts of interviews, autobiographies, diaries, letters, annual reports, mission statements, memoranda, musical scores, plays and novels" (Mouton, 2003:5). Mouton (2008) cautioned the researcher using existing information to consider accessibility, quality, the format and the transferability aspects. Also, if it is new information, the researcher should consider what methods of data gathering to use, getting access to the sources of such information and the capturing of such information once collected. Primary research was thus conducted in this study to complement the literature overview, where secondary sources were used to formulate six interim capability clusters to serve as basis for the identification of technology innovation leader competencies deemed to be required for successful technology innovation. Primary research sources used in this study are discussed next.

4.5.2.1. Experts

In Section 4.3.3 this study argued for reality as determined by the practitioners participating in the study. Primary research sources included experts in technology innovation leadership from both the public and business sectors. Experts were identified by the researcher through personal networks. Experts must have worked with or at executive level with sole or shared accountability, for managing technology innovation leaders with responsibility for technology innovation. Fourteen experts identified in Table 4.7 were interviewed during the qualitative phase of this study, of which seven were also on a list of eighteen experts identified in Table 4.12 who reviewed and validated the newly-developed measurement instrument during the quantitative phase of this study for use in the main survey of this study.

Experts interviewed were given an undertaking, by the researcher that their views would not be presented in a way which would link their inputs to their organisations or themselves personally. Accordingly, they are referenced in generic terms only.

4.5.2.2. Case materials

Case study research accommodates the analysis of multiple streams of data that may be quantitative and qualitative in nature or both (Quinlan, 2011:13) Technology innovation case materials are used in the qualitative part of this study and analysed through qualitative content analysis, as proposed by Quinlan (2011:429).

4.5.2.3. Practitioners

As discussed in Section 4.3.4, a pragmatic worldview was seen as important for the contribution envisaged for this study. This pragmatic worldview was brought about through expert involvement as well as practitioners participating in the study as practicing technology innovation leaders. A group of practitioners took part in a workshop on 24 November 2014 to convey their views of technology innovation leader competencies required for successful technology innovation, as discussed in Section 4.6.3, Section 4.7.3 and Section 5.2.3. Practitioners also contributed to the development and use of the pilot survey measurement instrument during a workshop on 24 July 2015, as discussed in Chapter 6.

4.5.3. Research sources contributions

Figure 4.6 shows the range of data sources used to obtain data during the two research phases that allowed the researcher to identify technology innovation leader capabilities for the transition to the quantitative second phase of this study where competencies were identified (presented as interim capabilities and behaviours at this stage), for quantitative assessment of the constructs and their hypothesised relationships.

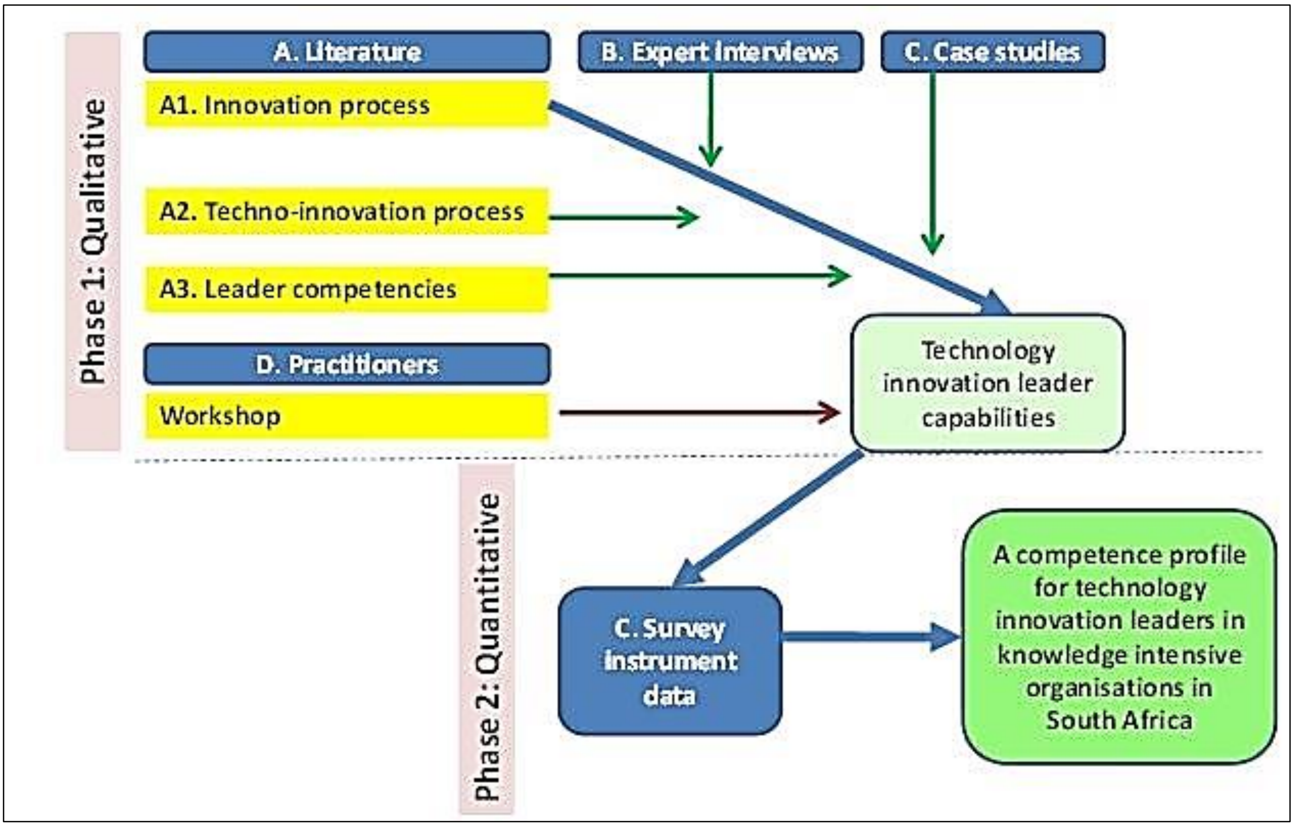


Figure 4.6: Research sources used for theory development

4.6. QUALITATIVE RESEARCH PHASE

Section 4.3.1 provided the overall research goal and research objectives for this study that are further discussed and extended below. Early attention to process perspectives was important in light of the literature overview in Chapter 3, and because innovation was defined as the process of turning ideas into reality and capturing value from them. Only if one can manage the whole process, is innovation likely to be successful (Tidd & Bessant, 2013:21).

The qualitative research phase pursued the following objectives in support of Research Objective 1 in Table 4.6, which aims to identify technology innovation leader competencies.

Table 4.6: Qualitative research objectives

Objectives	Related discussions
Objective 1: Obtain expert opinions on actual technology innovation processes used by successful technology innovation leaders.	Section 4.6.2 and Chapter 5
Objective 2: Obtain expert opinions on competencies of successful technology innovation leaders.	Sections 4.6.2, 4.7 and Chapter 5
Objective 3: Review innovation process assumptions in interim capability clusters as basis for identifying competencies through research themes.	Section 4.6.3 and Chapter 5
Objective 4: Supplement the opinions of experts on innovation process and competencies through additional sources of research data.	Sections 4.6.4, 4.6.5, 4.6.6, 4.6.7 and Chapter 5
Objective 5: Formulate concepts, constructs and items for inclusion in the measurement instrument for the quantitative second research phase.	Section 4.6.8 and Chapter 5

4.6.1. Experts' perspectives on the technology innovation process and competencies

As a common data collection method that allows for recording and transcribing content (Quinlan, 2011:221), one-to-one interviews were conducted as face-to-face engagements in which the researcher was the interviewer and each identified expert in Table 4.7 the interviewees. Expert opinions were used as primary research input into the identification of technology innovation leader competencies as discussed in Section 4.3.2.

Customised ethically compliant invitation messages were sent out by the researcher to individual experts listed in Table 4.7, whose actual names have been removed in the final dissertation, in accordance with the anonymity and confidentiality principles of the ethical clearance. The researcher followed up on these messages to arrange appointments for personal interviews of up to one hour each. Experts were alerted in the invitation messages that they would be asked to describe technology innovation processes and competencies of successful technology innovation leaders in their domain and that interviews would be recorded so that recordings could be transcribed and coded as research data.

Individual experts were identified through personal networks of the researcher. Experts had to have worked with or at executive level, with shared or sole accountability, for managing technology innovation leaders with responsibility for technology innovation. All the experts identified had gained exposure to both successful as well as unsuccessful technology innovation leaders and were thus able to articulate their views based on actual successes. The researcher attempted to interview a range of experts that would enhance diversity in terms of instituitions, professions, sectors and technologies as indicated in Tables 4.7 and 4.12 where ten of the listed experts were female, 15 had doctorate qualifications and seven had engineering qualifications.

Table 4.7: Expert opinions solicited during the qualitative research phase

#	Expert	Expertise	Inter-viewed
1	Expert (interviewed) 1	President Global Research Alliance, CSIR (India) Bhatnagar Fellow, innovation thought leader, National Chemical Laboratory; former CSIR (India) Head, Winner of awards for technology innovation, Co-author with Prahalad, Advisor on Global Innovation Index.	2012
2	Expert (interviewed) 2	Founder Innovation Leadership Forum London and Germany, innovation thought leader	2013
3	Expert (interviewed) 3	Vice President of the South African Academy of Engineering., Chairperson of the Council of the University, Founder Da Vinci Institute of Technology	2014
4	Expert (interviewed) 4	Science Council Executive Director Large Integrated Projects	2014
5	Expert (interviewed) 5	Group Executive Innovation Coca Cola Atlanta	2014
6	Expert (interviewed) 6	Petrochemicals Vice President: Strategic Research & Technology and CIBI. CEO of Science Council	2014
7	Expert (interviewed) 7	Telecommunications: Executive Network Architecture & Modelling	2014
8	Expert (interviewed) 8	Telecommunications: Managing Executive Retail Transformation	2014
9	Expert (interviewed) 9	MD of a listed company specialising in digital technologies	2014
10	Expert (interviewed) 10	MD listed company specialising in Security Systems	2014
11	Expert (interviewed) 11	Science Council Board member; Vice Rector Research and Innovation at a university	2015
12	Expert (interviewed) 12	Agency Executive: Innovation Enabling & Support Programmes, Innovation Hub, Industry executive	2015
13	Expert (interviewed) 13	Former Executive Director, Science Council building and construction sciences	2015
14	Expert (interviewed) 14	Agency Chairperson, SA Technology Foresight Study, Constrion company executive, Science Council Executive	2015

The experts listed in Table 4.8 indicated their willingness to participate, but were unavailable to do so when the interviews were scheduled.

Table 4.8: Experts supporting the study but unable to fit interviews into research schedule

Expert	Description
Expert (not available for interview) 1	Director General, University - Laureate winner 2007, BSc and an MSc from the University of Fort Hare and a PhD from the University of the Witwatersrand, Best managed Department Award 2013, CEO African Laser Centre, President/ Chair of UNESCO Science Commission.
Expert (not available for interview) 2	Science Council CEO & President, Vice Rector Research and Innovation of a university.
Expert (not available for interview) 3	Deputy Director General - Human Capital and Knowledge systems.

During prescheduled personal interviews with the researcher, the experts identified were asked to answer two questions. Each expert interview took up to an hour and was recorded and transcribed to allow for analysis of research data. Discussions with experts 1, 11, 12 and 14 in Table 4.7 were not recorded because of logistical constraints and the researcher improvised by using notes made during the discussion for analysis (Bryman & Bell, 2011:169). The experts were probed using the following questions:

Question 1. Most innovation processes found in innovation literature start with an idea and concludes with implementation of the idea. If you think of the technology innovation leaders that you have worked with, what is the real process or processes that they have adopted to achieve successful technology innovation?

Question 2. Based on your answer to the previous question and your experience, please describe what technology innovation leaders were competent at doing that you associate with successful technological innovation.

Analysis of the expert interviews commenced after the recorded interviews were transcribed and subjected to the content analysis of both questions posed. The analysis informed the review of interim capabilities and populated the technology innovation leader capabilities for inclusion in the survey instrument used in the quantitative second phase of this study. Innovation process findings are discussed in Chapter 5, while leader competency findings are discussed in Chapter 6.

In light of innovation process assumptions made in Chapter 3 and as reflected in the interim capabity clusters that were adopted as research themes, early inputs from experts were envisaged to ensure that all innovation process responses of experts were accommodated before using these clusters as research themes to identify competencies, as presented in Chapter 5.

Case material analysis, practitioners' workshopping and research theme-related literature studies were further used to reinforce the validity of the ensueing research themes as basis for the identification of competencies.

4.6.2. Case analyses of technology innovation processes

Babbie and Mouton (2008:280-281) explained the troubled history of case study-based research before it became more "scientifically respectable" in recent years. For a researcher to derive the benefits of case study research, Babbie and Mouton (2008: 282-283) emphasised the importance of deliberate pre-research design principles of effective case study research. These principles include its conceptual design, integration of contextual detail, the use of multiple sources of data and the selection of analytical strategies in the case study research.

Bryman and Bell (2011:59) acknowledged the work of Eisenhardt and Graebner (2007) to popularise the case study research method. Like Babbie and Mouton (2008), they emphasised the importance of case study design to yield its benefits and claimed that some of the best-known studies in business and management research had been based on this design. The limitations of case study research (Bryman & Bell, 2011:59-60) may be found in its relative strengths, namely its focus on a single organisation, a single location, a person or event. The guiding considerations for mitigation of countering the often very legitimate challenges of case research come from Eisenhardt and Graebner (2007). They proposed precise language and thoughtful research design, careful justification of theory building, theoretical sampling of cases, effective presentation of evidence, and the clear statement of theoretical arguments to produce fresh theory derived from qualitative evidence (Eisenhardt & Graebner, 2007).

This research adopted case analysis as a qualitative research strategy and an inductive approach with "multiple or collective cases that are undertaken jointly to explore a general phenomenon", where the aim is to produce insights "that are located in situational context" through using multiple data collection methods to uncover conflicting meanings and interpretations (Bryman & Bell, 2011:60-61). The following cases were analysed for their revelatory contributions to both the technology innovation process discussion, as well as to identify technology innovation leader competencies deemed to be required for successful technology innovation, which is the primary aim of this study:

- The 1961 speech by former President J.F. Kennedy entitled *We choose to go to the moon*, was labelled as "a speech that changed the world" (Lowne, 2007: 72).
- The 2013 film entitled *Steve Jobs*, in which some of the technology innovation leader capabilities of the founder and former CEO of Apple Computers are portrayed (Isaacson, 2011).
- Technology innovation cases from a building technology research and innovation unit of the CSIR (Vlok & Page-Shipp, 2015).
- Thirty science-derived innovation cases from South Africa in a publication on scientific breakthroughs that resulted in successful technology innovation (Wild, 2015).

Case materials were coded and analysed using MS Excel software for the identification and refinement of concepts and constructs. Cases provide a basis from which to develop theory inductively by recognising patterns of relationships among constructs within and across cases to produce testable theoretical propositions (Eisenhardt & Graebner, 2007).

4.6.3. Practitioners workshop perspectives on technology innovation processes

A group of 34 technology innovation leaders in a bio-sciences environment participated in this research during a workshop on 24 November 2014 where their individual and collective views of their desired future leadership were recorded and analysed. The results are discussed in Chapter 5.

4.6.4. Targeted further literature review on innovation processes for success

Literature reviews in Chapter 3 revealed apparent inadequecies of traditional linear sequential innovation processes and apparent contradictions in philosophical points of departure that have different implications for the identification of technology innovation leadership competences deemed to be required for successful technology innovation.The early capturing and synthesis of expert opinions on actual technology innovation processes used by successful technology innovation leaders provided more clarity on process dynamics that may have to be accommodated in technology innovation competencies.

Research data from case materials and practitioner workshopping endorsed and complemented expert views in Appendix A and triangulated perspectives in Appendix E. These research inputs, as well as researcher observations made during expert interactions, review of case materials and practitioner workshopping, necessitated further reading on process perspectives to enhance the researcher’s understanding of innovation process requirements for technology innovation leader competencies directed at successful technology innovation.

4.6.5. Triangulation of qualitative research data on technology innovation processes

Triangulation means examining the research issue or phenomenon from more than one perspective to answer the research question (Quinlan, 2011:42). Triangulation also entails using more than one method or source of data in the study of social phenomena (Bryman & Bell, 2011:397). The use of “between methods” triangulation is proposed by Quinlan (2011:42) to provide a more valid view of that phenomenon by using interviews, observations and focus groups. In this study, triangulation was done between expert interviews, case analysis, practitioner workshops and targeted literature reviews. Uncertainties were expressed in Chapter 3 about actual technology innovation processes used in practice as basis to identify leader competencies. The researcher used triangulation to increase the validity (Bryman & Bell, 2011:234) of interim capability clusters derived from deconstruction of process models found in literature, through triangulation with other sources, including expert opinions, case material and practitioner inputs as illustrated in Figure 4.7. Additional sources identified by the researcher were found to be inaccessible, such as competency modelling practices and existing leadership competency models used by organisations. Unfortunately, the models identified for possible use in the study are typically not in the public domain and are only accessible through IP agreements or attendance of leadership programmes that make use of these models. Consequently, this study could only refer to such models if they became accessible in the public domain or via social media plarforms that hosted professional practitioners' conversations.

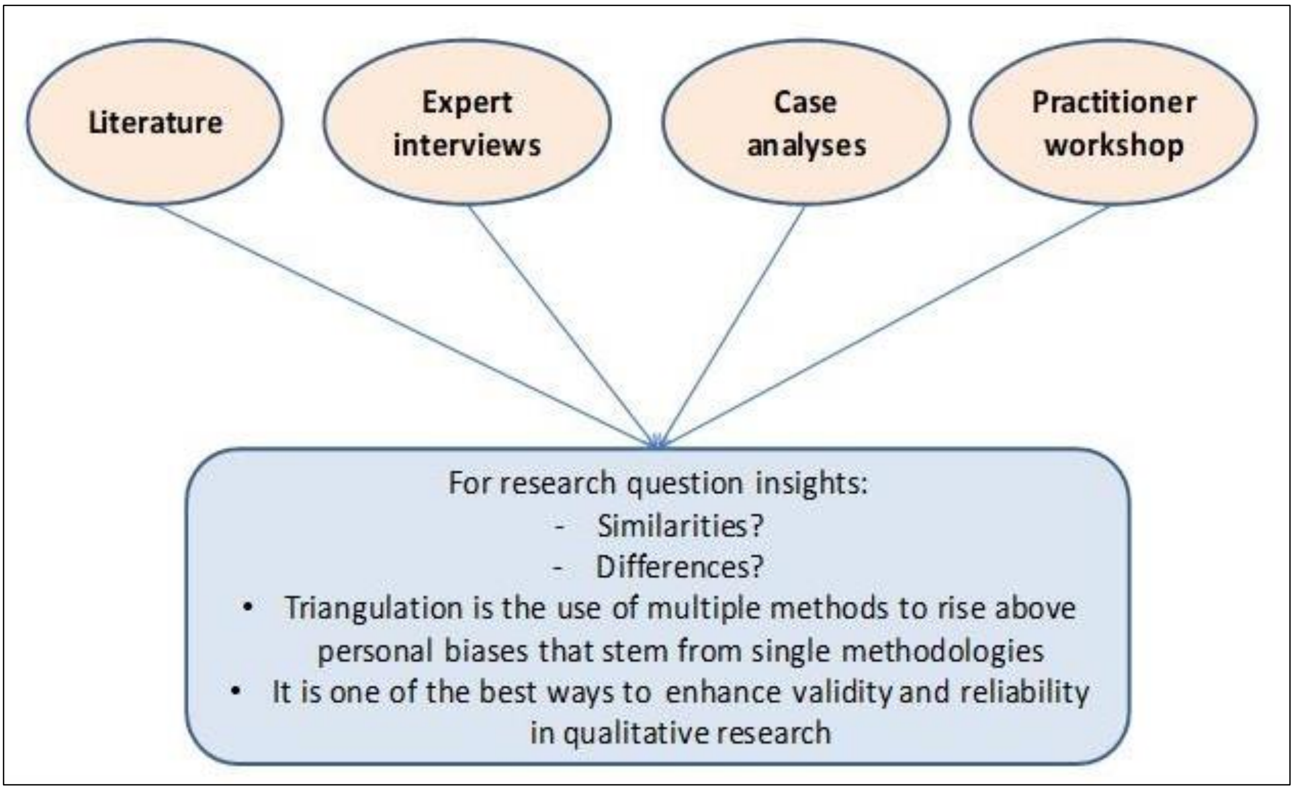


Figure 4.7: Triangulation of research sources for theory building

Sources: Adapted from Babbie & Mouton, 2008; Bryman & Bell, 2011; Quinlan, 2011.

Chapter 3 argued for the adoption of a process orientation to identify technology innovation leadership competences. Literature sources differed significantly about the start and end of innovation processes, as well as the steps involved and their sequence. The deconstruction of processes in Chapter 3 resulted in an interim set of context-related capability clusters that were subjected to research data obtained from expert interviews and the findings are reported in Chapter 5. Interim innovation process assumptions were further subjected to research data from case materials, practitioner wokshops and literature studies as contemplated in Section 4.5.3 and further discussed in Section 4.6.5 that deals with qualitative content analysis.

4.6.6. Coding of qualitative research data for content analysis

The articulation of a coding paradigm is discussed by Rizzo and Fulford (2012:302) who claimed that the researcher should, at some point in the research "...where initial categories and sub-categories start to emerge ... decide whether or not to adopt a pre-established coding paradigm".

4.6.6.1. Coding paradigm

The processing of qualitative research data obtained from the sources used in this study adopted a pragmatic approach based on early and consistent coding during content analysis, as advocated by Bryman and Bell (2011: 585). Bryman and Bell (2011) argued that early coding assists the researcher to understand the available data and helps with theoretical sampling during the study, while also alleviating feelings of being swamped by data, which may happen when analysis of data is deferred to the end of the data collection period. Bryman's four-phased qualitative analysis, as summarised in Table 4.9, was used for linking chunks of data or text as representative of the same phenomenon. While traditional content analysis "seeks to quantify content in terms of predetermined categories in a systematic and replicable manner" (Bryman & Bell, 2011: 289), Bryman's qualitative analysis does not involve counting (Bryman, 2015).

Table 4.9: Bryman's four-phased qualitative analysis

Stages		Activity
1	Read	• Read the text and make notes at the end. • Look for what the text is all about. • Identify major themes. • Look for unusual issues or events. • Group cases into types of categories that may reflect the research question.
2	Read again	• Mark the text (underline, circle or highlight). • Add marginal notes or annotations. • Labels for codes. • Highlight key words. • Note any analytical ideas suggested.
3	Code the text	• Systematically mark the text. • Indicate what chunks of text are about and index them as themes. • Review the codes. • Eliminate repetition and similar codes (combine). • Think of groupings. • You may have many codes at early stage that can be reduced later.
4	Relate general theoretical ideas to the text.	• Coding is only part of the analysis. • You must add your interpretation. • Identify significance. • Review interconnectedness between codes. • Relate codes to research question and research literature.

Source: Bryman, 2015.

4.6.6.2. Coding for qualitative content analysis

Bryman and Bell (2011:289) defined content analysis as "...an approach to the analysis of documents and texts (which may be printed or visual) that seeks to quantify content in terms of predetermined categories and in a systemic and replicable manner". Stemler (2001:1) added that this technique allows the researcher to compress many words of text into fewer content categories by applying explicit rules of coding. Content analysis is also used to discover and describe the focus of individual, institutional or social attention and inferences can be made that can be corroborated by other methods of data collection. The use of content analysis is also "...motivated by the search for techniques to infer from symbolic data what would be either too costly, no longer possible, or too obtrusive by the use of other techniques" according to Krippendorff (1980, as cited by Stemler, 2001:2).

Babbie and Mouton (2008:492) divided content analysis "...into two types, namely conceptual analysis and relational analysis" with conceptual analysis previously also known as "thematic analysis". "Qualitative content analysis" is described by Mouton (2003:166) as one of the "more specialised design types" which "... is usually aimed at public documents, especially editorials in newspapers and magazines, letters, political speeches, annual reports, and so on".

This study focuses on the identification of technology innovation leader competencies that are deemed to be required for successful technology innovation. Such exploratory research questions allow for the selection of cases ranging from probability sampling to theoretical sampling and the use of qualitative content analysis or quantitative content analysis as design types (Mouton, 2003). Qualitative content analysis was used in the first phase of this study because the "...analysis of texts and documents is an unobtrusive (non-reactive) method, which means that errors associated with interaction between researchers and subjects (such as observation effects) are avoided" (Mouton, 2003:166).

Content analysis requires the coding and categorising of the data. A 'category' is described as a group of words with similar meaning or connotations and categories must be mutually exclusive and exhaustive. Mutually-exclusive categories exist when no unit falls between two data points, and each unit is represented by only one data point (Stemler, 2001:4).

A priori coding was used in this study which means that:

> *...the categories are established prior to the analysis based on some theory. Professional colleagues agree on the categories, and the coding is applied to the data. Revisions are made as necessary, and the categories are tightened up to the point that maximizes mutual exclusivity and exhaustiveness.* (Stemler, 2001:4)

Palmquist (1993, cited in Babbie & Mouton, 2008:491) claimed that:

> *...by examining the presence or repetition of certain words and phrases ... a researcher is able to make inferences about the philosophical assumptions of a writer, a written piece, the audience for which a piece is written, and even the culture and time in which the text is embedded.*

Table 4.10 shows Babbie and Mouton's (2008:492) eight steps used in this study that make up a conceptual analysis.

Table 4.10: Application of conceptual analysis steps

	Steps	**Study application**
1	Deciding at what level to analyse data.	Direct or implied reference to technology innovation leader process and leader competencies reflected in leader behaviour represented by verb and noun paired descriptions.
2	Deciding how many concepts to code for.	Six interim *a priori* codes from interim capability clusters
3	Deciding whether to code for existence or frequency of a concept.	Code for existence.
4	Deciding how to distinguish among concepts.	Parent-level constructs (capability clusters) with child-level items (competencies or behaviours)
5	Developing rules for the coding of texts.	Initially allocate one of n codes and extend n or split into potential constructs and items.
6	Deciding what to do with irrelevant information.	Irrelevant data will not be used, i.e. data that does not address the research question.
7	Coding texts.	Done throughout qualitative phase when triangulated sources are analysed.
8	Analysing results.	Done at the end of the qualitative phase as basis for questionnaire development.

Source: Adapted from Babbie & Mouton, 2008:492.

4.6.6.3. Theory implications of coding paradigms

A "commonly mentioned criticism of the coding approach to qualitative data analysis is the possible problem of losing the context of what is said" (Bryman & Bell, 2011:588). Some authors' contributions are only available in the form of composite statements that the researcher could interpret in multiple ways. This resembles a phenomenon referred to as "rater bias" discussed in Chapter 2, and such bias is suppressed by selecting items "in a consistent manner" (Bryman & Bell, 2011:290). While some forms of data may not be suitable for the coding method, the researcher considered narrative analysis instead, based on the understanding that a researcher's work "can acquire significance only when you theorize in relation to it" by reflecting, interpreting and theorising on research data (Bryman & Bell, 2011:589).

Theorising would thus require researcher awareness of the paradox between what is observable and what may become observable. Leaders apply observable, learnable sets of practices which mean that leadership is not something mystical and ethereal that cannot be understood by ordinary people. Given the opportunity for feedback and practice, those with the desire and persistence to lead; to make a difference, can substantially improve their abilities to do so (Kouzes & Posner, 1995: IV).

> *For years, we defined leadership as an influence process ... in recent years, we have taken the emphasis away from goal accomplishment and have defined leadership as the capacity to influence others by unleashing their power and potential to impact the greater good ... when the definition of leadership focuses on goal accomplishment, one can think that leadership is only about results ... Leadership should ... have a much higher purpose than that.* (Blanchard, 2010: xvi-xvii)

4.6.6.4. Analytical induction

When analysing data as part of an inductive research strategy, it may be difficult to deal with the emergence of themes in data that do not relate to theories identified during the literature review. This typically happens during semi-structured interviews when respondents go into areas not covered in the interview schedule or the literature reviewed. Inductive research is iterative to allow for theory building, "...involving tracking back and forth between theory and data" (Bryman & Bell, 2011: 573). By exploring "more themes and dealing with an ever-broader set of literature, there is a risk of trying to cover too much within the dissertation and the student's ...engagement with theory and analysis of the data consequently becomes too superficial" which calls for achieving a balance" (Bryman & Bell, 2011:573).

Bryman and Bell (2011:574) extended their discussion on qualitative data analysis by proposing a process of analytic induction as outlined in Figure 4.8, which served as basis for reviewing the initial coding used for content analysis in this study.

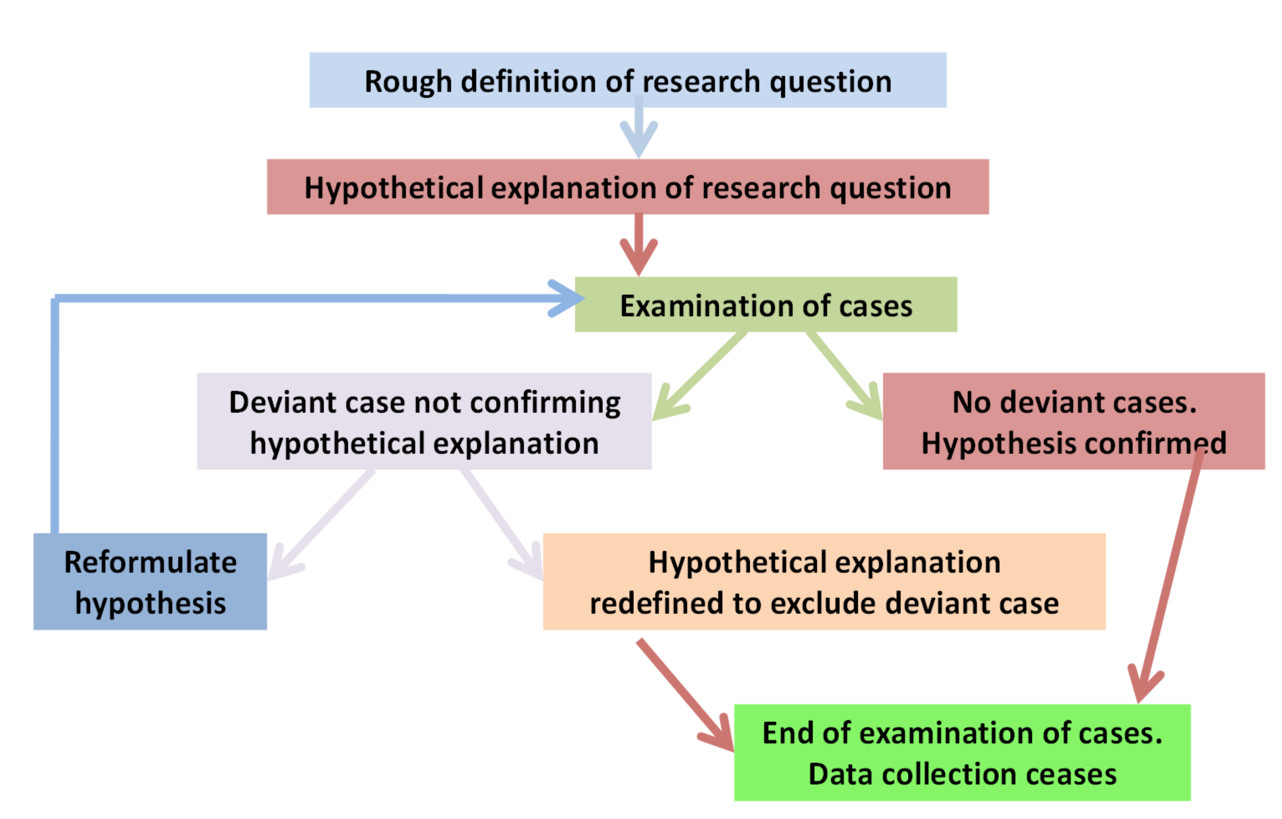


Figure 4.8: The process of analytical induction

Source: Bryman & Bell, 2011: 574.

A broad definition of the research question in this study is: "Which technology innovation leader competencies are deemed to be required for successful technology innovation?"

The hypothetical explanation of the research question which explains the initial coding used in this study was based on a linear, sequential management paradigm as discussed in the innovation process discussions of Chapter 3. During examination of cases it became evidently clear, however, that literature, as well as domain experts increasingly acknowledge that technology innovation does not necessarily follow a linear sequential flow. This kind of insight is accommodated by Babbie and Mouton (2008:493) who explained that:

> *...coding involves a process whereby certain segments of your text are attached to certain meaningful key labels or codes. In practice, this involves reading and re-reading your texts, trying to make sense of the patterns and themes that emerge from your data.*

In an expert interview with a London-based expert in 2013 and in the South Africa's Bio-economy Strategy reference was made to a "non-linear innovation pipeline" by the Department of Science and Technology ((2013:11,14). Later in the same document the following is stated:

> *The National Biotechnology Strategy supported a linear model of science, technology and innovation. In this model, universities generate basic knowledge, which science councils then exploit and translate into innovative technologies that can be commercialised by industry. As a result, there is considerable activity in basic research (by universities) and applied research (by science councils).*
>
> *While this is one model of science innovation – and has been instrumental in identifying gaps and inefficiencies in value chains – mature bio-economy systems have more complex models that include 'industry pull', where applied research (whether academic, by a science council or a firm's research division) is guided by an industry's needs. Some models also use 'inward technology transfer', where successful technologies are imported and adapted to the local environment and market. The most successful and mature bio-economies, such as the United States of America and Switzerland, use a model that focuses on creating an enabling environment for biotechnology and related fields by implementing a suite of incentives to stimulate innovation and allow all stakeholders – the government, industry and academics – to interact and extract value from biotechnology. It should be noted that models can co-exist and complement each other.*

After the above insight into the emerging new paradigm, the initial "coding frame" (Bryman & Bell, 2011: 249) was changed to reflect a non-linear innovation process paradigm as indicated in the innovation process review discussions in Chapter 3. The revised coding frame adopted interim capability clusters that served as codes for later review and hypothesis formulation, questionnaire development and testing of a hypothesised competency model for technology innovation leaders in line with the title and objectives of this thesis.

4.6.7. Suitability of research themes for identification of competencies

Research data obtained from the respective preceding research sources were interpreted to adjust or confirm the suitability of research themes for the identification of technology innovation leader competencies deemed to be required for successful technology innovation. Research themes were confirmed, but slightly adjusted for greater clarity by extending their descriptions to guide the identification of leader competencies, as presented in Chapter 5.

Figure 4.9 summarises the decomposition of innovation processes reflected in Table 3.4, the identification of interim capability clusters in Table 3.6 and their adjustment in light of new insights as shown in Table 3.14, and resulting in research themes from the theoretical framework from Figure 3.33 to guide the identification of technology innovation leader competencies in Chapter 5.

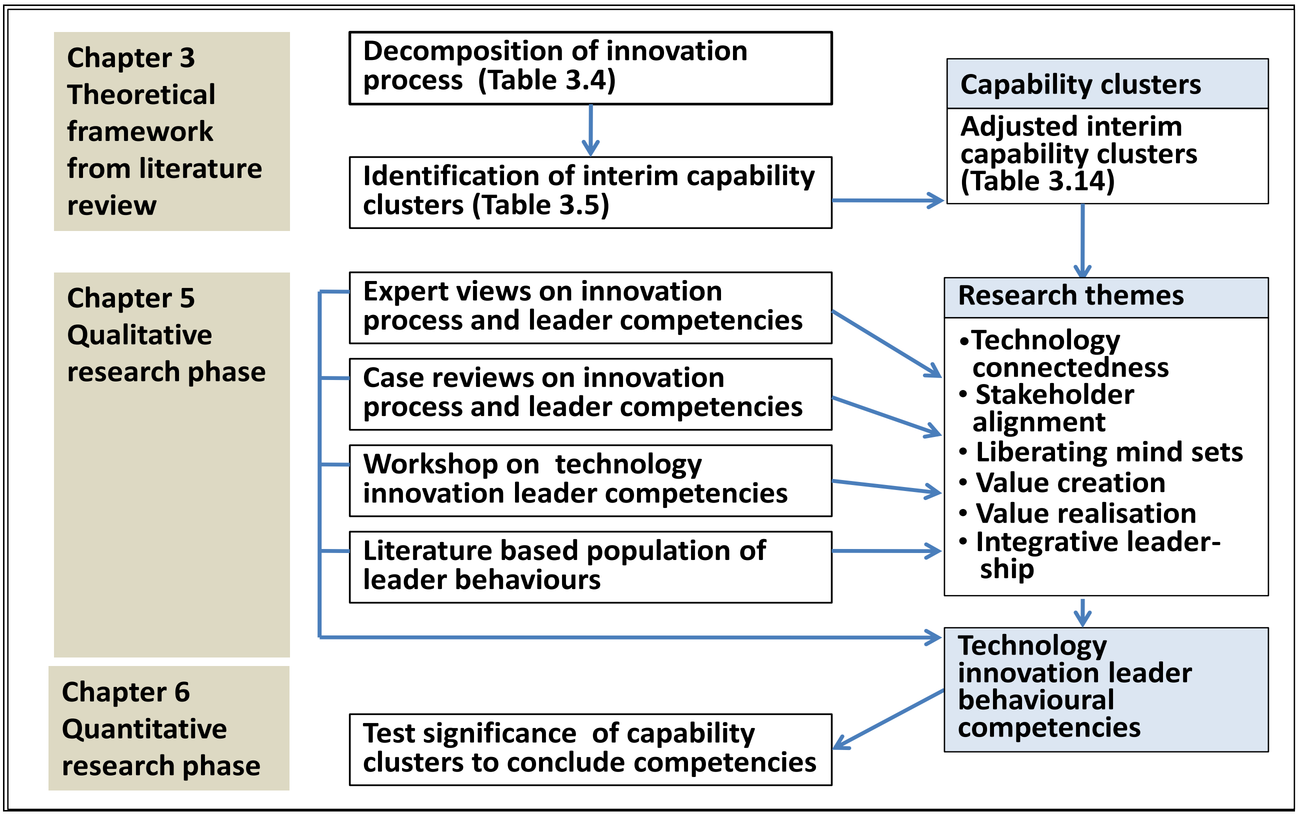


Figure 4.9: Capability clusters reviewed as research themes

4.6.8. Populating research themes from research data

Each of the research themes was populated with behaviours identified from the qualitative research sources used.

During coding of research data, the researcher observed that coding tended to itemise observations that may obscure the possible significance of any interconnectedness between leader competencies. Friedman (2008:5) shared a perspective on interconnectedness, referred to as "Total Leadership" to sensitise leaders to the benefits of alignment between the work, home, community and self-components of their lives, not by trading off one for another, but finding mutual value among them.

Friedman (2008) extended these claims to propose that most leaders are reluctant to experiment with newness because they associate it with increased risk and less control. Friedman (2008) believed that leaders who have clarity on their core values, leadership vision, and alignment between their actions and what they regard as important, are more likely to experiment and venture into newness. This insight has influenced the researcher's coding to aim for understanding relationships between observed leader behaviours in deciding on their categorisation when populating the interim capability clusters or research themes (Bryman, 2015).

4.6.9. Formulation of concepts, constructs and items from content analysis

Constructs make up the concepts being used in research. Clark and Watson (1995) began with a clear conceptualisation of the target construct, followed by an initial item pool which they suggested should be over-inclusive and item wording needs careful attention. The item pool should then be tested, along with variables that assess closely-related constructs, on a heterogeneous sample representing the entire range of the target population.

Figure 4.10 illustrates how this process was conducted, specifically how the interim capability clusters used as research themes were used as primary codes for content analysis of research data obtained from four research souces in response to two questions posed to experts and confirmed by other sources, resulting in 109 behavioural codes clustered into 60 items after removing duplicates.

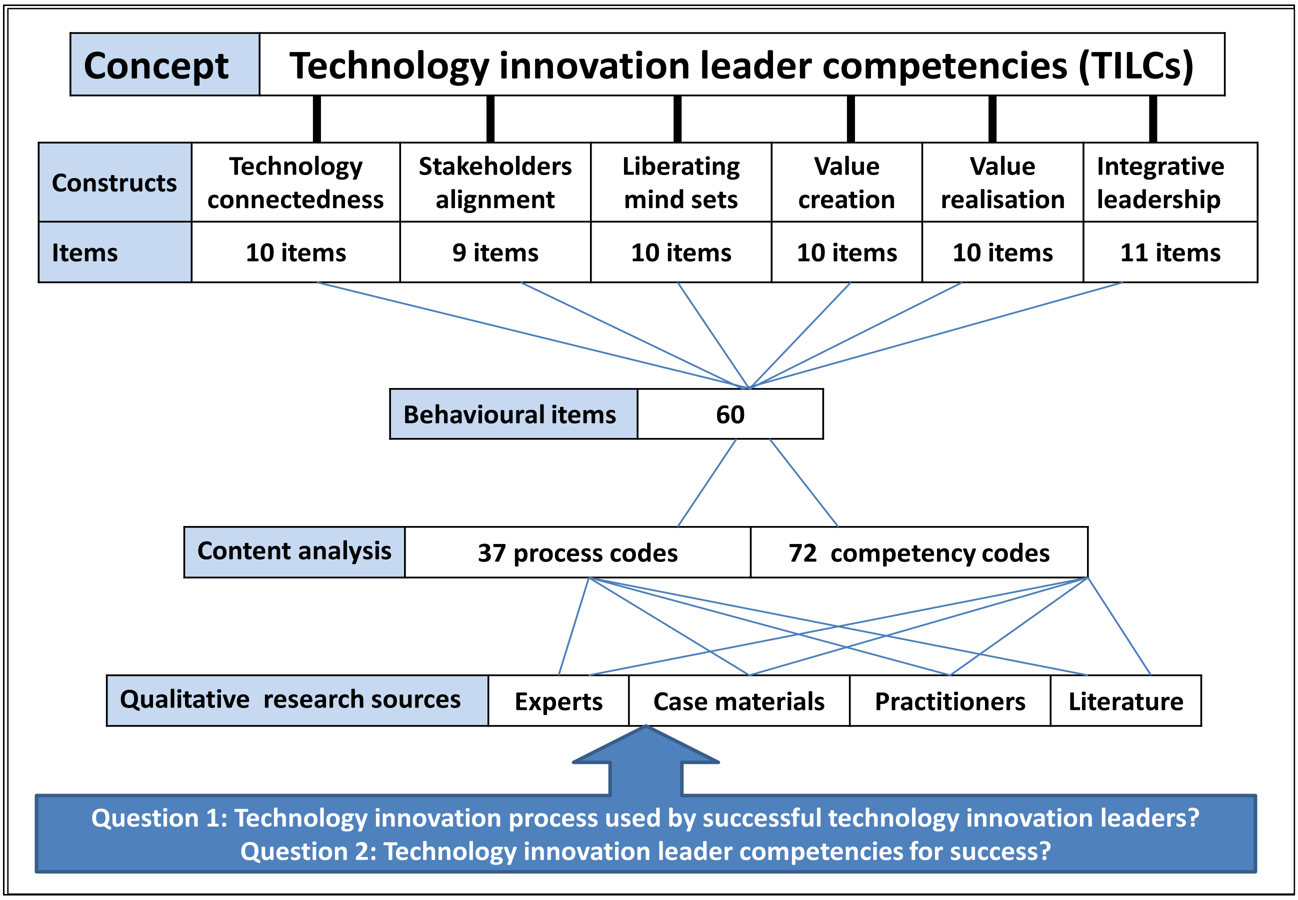


Figure 4.10: Formulation of conceptual constructs

4.7. LEADER COMPETENCY DATA FROM QUALITATIVE RESEARCH SOURCES

During the review of innovation process perspectives early coding was applied as suggested by Bryman and Bell (2011:585). The same coding frame was then applied to qualitative research data obtained from the the same qualitative research sources used for the innovation process review, to identify sets of technology innovation leader behaviours deemed to be required for successful technology innovation. These results are presented in Chapter 5.

4.7.1. Expert opinions on technology innovation leader competencies

Expert opinions on technology innovation leader competencies deemed to be required for successful technology innovation were captured as their responses to the second question posed during the expert interviews as discussed before.

4.7.2. Case materials on technology innovation leader competencies

The case materials used to verify innovation process assumptions and capture process perspectives of relevance to the identification of leader competencies in the previous section, were also used, together with other identified case materials, to identify leader competencies to populate research themes.

4.7.3. Practitioners' inputs on technology innovation leader competencies

The same practitioners' workshop results used to identify innovation process perspectives of relevance to leader competencies as discussed before in Section 4.5.2.3, were used to identify technology innovation leader competencies deemed to be required for successful technology innovation.

4.7.4. Targeted further iterature review on technology innovation leader competencies

The same procedure used during the technology innovation process review before was used to identify technology innovation leader competencies deemed to be required for successful technology innovation.

4.8. EMERGING ELEMENTS OF A TECHNOLOGY INNOVATION LEADERSHIP THEORY

The population of research themes with behaviours from qualitative research data provided the concepts, constructs and items that make up technology innovation leader competencies for empirical testing during the quantitative second research phase.

In light of discussions on task partitioning theory in Chapter 3 and the theory generation objectives of this study, this section provides a coherent, integrative view of research themes as potential elements of an emerging theory.

4.9. PRE-QUANTITATIVE PHASE REFLECTIONS

Researcher curiosity inspired the matching of constructs derived from the qualitative research phase with lessons and quotations by the late Steve Jobs, one of the best known and most successful technology innovation leaders (Isaacson, 2011). The results are presented in Chapter 5, Table 5.10.

4.10. GOOD RESEARCH PRACTICES IN THE QUALITATIVE RESEARCH PHASE

Section 4.1 proposed good research practices for this study. Chapter 2 dealt with the researcher's experience and potential bias which is why Research Objective 4 was included in Table 4.1. Based on the personal experience of the researcher in the domain being researched, a research challenge identified by Mouton (2003:106-107) as the "research selectivity effect" was acknowledged, suggesting that the researcher may be biased in the choice of which data to observe or ignore. Caution was thus exercised to ensure that rigorous scientific protocols were applied throughout the study, which should be evident in the range of resesearch sources used and extensive items pool subjected to coding for content analysis and the identification of concepts, constructs and behavioural items as per the five qualitative research objectives in Table 4.5.

4.11. QUANTITATIVE RESEARCH PHASE

4.11.1. Research goal and objectives

The qualitative phase of this study provided clarity of concepts, constructs and items. The quantitative phase of this study aimed to gather research data that could be used for analysis related to the research question and the research objectives in Table 4.11 that were derived from the overall research goal and the remaining research objectives listed in Table 4.2.

Table 4.11: Quantitative research objectives

Objectives	Related discussions
Objective 1: Obtain demographical details of respondents to serve as basis for comparing the sample to the study population.	Section 6.3.1
Objective 2: Obtain respondents' views on what technology innovation success entails.	Pilot and main surveys
Objective 3: Obtain respondents' ratings of the significance of identified technology innovation leader capabilities deemed to be required for successful technology innovation.	Pilot and main surveys

The next section addresses the development of the survey measurement instrument to pursue the research objectives listed in Table 4.11.

4.11.2. Development of the survey measurement instrument

In research design, survey research involves the questionnaire construction, sample selection and data collection (Babbie & Mouton, 2008). An online secure survey questionnaire was developed, validated and operationalised in the qualitative main survey phase of this study. The questionnaire was used as a method to collect research data from a sample of respondents from the specified population by asking them to respond to questions by indicating their selection from different points of view (Babbie & Mouton, 2008).

4.11.2.1. Concepts, constructs and items

The technology innovation leadership competencies concept, its constructs and items identified during the qualitative first research phase, as visually illustrated in Figure 4.10, served as the input for constructing a draft questionnaire. This concept, its constructs and items were derived from the qualitative first phase of this study as interim capability clusters to be incorporated into the survey measurement instrument for assessment of the significance of identified behavioural items during the main survey of the quantitative second research phase.

4.11.2.2. Measurement instrument: development of a draft questionnaire

A survey research method allows for gathering data from large populations and geographically scattered samples (Quinlan, 2011:43). In this study, a three-part questionnaire was developed and used as a measurement instrument to obtain research data during the quantitative research phase, of which the pilot survey version is shown in Appendix H and the final version in Appendix I. The questionnaire design met the following requirements in support of the research goal and objectives:

- An introductory section provided the title of the study, an outline of the questionnaire as well as the contact details of the researcher and an informed consent section linked to the principles of the ethical clearance.
- Completion time: Experienced colleagues of the researcher suggested that the questionnaire should not take more than 20 minutes to complete because of the target population being senior and busy people, and that respondents should be given two weeks for completion.
- The University's ethics committee conditions for this type of survey made participation voluntary, confidential and anonymous. Provision was made, however, for respondents to share the following biographical details in Part 1 of the questionnaire:
    - Gender
    - Age
    - Number of years as technology innovation leader
    - Highest qualification

  - Main discipline studied (Technician/ Natural sciences/ Behavioural sciences/ Business management/ Engineering/ Other)
  - Job focus (Junior management/ middle management/ senior/executive management/ technical domain specialist/ Functional domain specialist/ Other)
  - Organisation size (number of employees)
  - Organisation type (SME/ University/ Research council/ Industry/ Consulting/ Other)

- A 5-point Likert scale was used for respondents to indicate their levels of agreement with statements in the questionnaire:
  - To no extent (1)
  - To a little extent (2)
  - To some extent (3)
  - To a great extent (4)
  - To a very great extent (5)

- Part 2 of the questionnaire included introductory questions relating to innovation, the technology innovation process and the constructs for respondents to indicate their levels of agreement with innovation-related terms and assumptions, as well as success orientation as the extent to which the technology readiness levels discussed in Chapter 3 were regarded as technology innovation success indicators as indicated in Appendix H. As discussed in Section 4.11.2.6, the technology readiness level had to be replaced by a set of technical, business and people success indicators (Appendix I) based on the pilot survey results.
- Part 3 of the questionnaire included the six capability clusters and 60 items from Figure 4.10 for respondents to indicate the extent to which they regarded the listed competencies as being important for successful technology innovation.
- The questionnaire concluded with a short message to thank respondents for their participation.

4.11.2.3. Expert validation of the draft instrument

Face validity is a subjective assessment of whether the measurement instrument appears to be a valid measure of the concept, constructs and item variables (Bryman & Bell, 2011). The 18 experts listed in Table 4.12 were individually approached by the researcher and requested to assist in establishing content validity of the draft survey instrument by reviewing if the questionnaire measured what it should and if the questions supported the research question.

Experts were also asked to share their opinions on the questionnaire related to it being understood and where improvements could be made. As was the case for obtaining expert opinions during the qualitative first research phase, experts were defined as senior to executive level managers with experience in technology innovation and the management of technology innovation leaders. Seven of the experts in Table 4.12 also appear in Table 4.7 because they had provided expert opinions during interviews conducted in the qualitative research phase.

Twelve of the 18 experts also completed the draft questionnaire, during their validity reviews, but these results were excluded from an analysis of the pilot survey.

Feedback from experts was generally positive and the few improvement suggestions received and implemented all related to minor changes in wording for greater clarity. No structural changes were suggested or made and the questionnaire was thus assumed to be sufficiently validated for use in a pilot study.

Table 4.12: Expert validation of draft measurement instrument

#	Expert	Expertise	Validation *= also interviewed
1	Expert (validation) 1	Science Council Executive Director Large Integrated Projects, enterprise creation and development	Yes*
2	Expert (validation) 2	Telkom Managing Executive Retail Transformation	Yes*
3	Expert (validation) 3	MD of a listed company specialising in security systems	Yes*
4	Expert (validation) 4	Science Council Board member; Vice Rector Research and Innovation at a university	Yes*
5	Expert (validation) 5	Science Council Chief Technologist	Yes
6	Expert (validation) 6	TIA Executive: Innovation Enabling & Support Programmes, Innovation Hub.	Yes*
7	Expert (validation) 7	Former Executive Director, Science Council Built Environment	Yes*
8	Expert (validation) 8	Executive Director National Laser Centre	Yes
9	Expert (validation) 9	SKA Manager, former head of a UK London-based technology innovation consultancy firm	Yes
10	Expert (validation) 10	Global Research Alliance Secretariat	Yes
11	Expert (validation) 11	Chairperson TIA, SA Technology Foresight Study, Innovation Executive at construction company, Science Council executive, University Board member	Yes*
12	Expert (validation) 12	CEO Global Research Alliance, Head International Relations of Science Council	Yes
13	Expert (validation) 13	CEO Space technologies and commercial services, board appointments.	Yes
14	Expert (validation) 14	Group Manager Human Resources Media24	Yes
15	Expert (validation) 15	Director Technology Transfer(university); Director Research & Consulting Support; Vice President, Innovation and Technology Transfer, SARIMA	Yes
16	Expert (validation) 16	Former Science Council Business Development Manager, EU projects liaison, environmental consulting.	Yes
17	Expert (validation) 17	Senior Director, University	Yes
18	Expert (validation)	CEO incubation centre, University	Yes

4.11.2.4. Pilot survey

The “testing out” of a newly-developed measurement instrument is referred to as a pilot survey and is typically conducted, as in this study, by administering the instrument to a limited number of subjects from the same population as that for which the eventual project is intended (Welman *et al.,* 2012:148). According to Welman *et al.* (2012:148), the purpose of a pilot survey is to reveal and address possible flaws in the measurement procedures, such as ambiguous instructions, inadequate time limits, as well as the operationalisation of the independent variable(s).

The pilot survey was completed by a convenience sample of 23 technology innovation leaders during a workshop on 24 July 2015, as well as 29 respondents (18.1% response rate) to an email invitation sent by the survey administrator to 160 eligible candidates nominated by previous colleagues of the researcher between October and December 2015. Descriptive statistics on demographic data was not recorded for the pilot study.

Pilot survey data from completed measurement instruments were statistically analysed by means of STATISTICA software to identify and eliminate any possible test items that did not contribute to the internal consistency of the instrument and to ensure reliability and validity before proceeding with a main survey (Swart, 2013).

Innovation beliefs of respondents were captured by asking them to what extent they agreed or disagreed (i) that technology innovation is achieved when value is derived from its adoption or deployment, (ii) that technology innovation processes may not take place in a linear sequential manner and (iii) that identified capability clusters would feature in their technology innovation processes. The findings presented in Chapter 6 suggested early support for innovation process and capability cluster assumptions made in Chapter 3. This field was left in the main survey instrument as an additional source of data, should the main survey results differ from the pilot survey results. The main survey results, however, were very similar and are thus not further discussed.

The following unsolicited qualitative feedback received from the pilot survey may be interpreted as positive support for the study and an indication of the perceived severity of the knowledge gap discussed:

- “Your project looks great” (Anthony, JPS).
- “It does not matter if you are in the public or private sector – innovation is needed to remain competitive and meet changing expectations; this pioneering research has local and international relevance” (industry executive).
- “Fantastic to see new thinking that challenges our assumptions as leaders” (tech transfer office).
- “This will help leaders to think differently about the influence of their behaviours on innovation” (agency executive).
- “Very interesting; I am keen to see the results” (Professor MM and start-up technology entrepreneur).
- “I fully concur with your thinking” (utility company executive).
- “Companies are investing in SA innovation such as GE’s recent R500 million innovation centre in South Africa” (techno-innovation leader).

- “Innovation in RSA is urgently needed, at the human-process interface. We cannot afford to go the ‘latest tech gadget’ way. Our population’s societal abilities and expectations are so far removed from ‘original designer’s intent’ of these innovative concepts, that we need to consciously adapt/adopt a ‘*boer moet plan maak*’ approach regarding our ‘innovative’ ideas and concepts” (Kiderlen Ashway PrEng).
- *Ek kry daagliks talle innoverings-navrae. Groot firmas wat nuwe dinge wil doen op nuwe maniere – wat probleme het wat hulle wil oplos. Die geleenthede is baie groot, en die tyd is min, maar die rede waarom dit BAIE BAIE BAIE makliker is om ‘n Microsoft in VSA te bou as in Suid Afrika is nie dat ons nie die resep het nie, of weet hoe om dit te benader, beplan of uitvoer nie. Dit is omdat die omgewing en kultuur rondom ons 100 percent teen ons is. Dit is asof die omgewing alles in sy vermoë doen om tegnologiese sukses in SA te stuit. Die enigste rede waarom ek en ander nog voort stoei – en ons groei redelik goed – is omdat ons nog nie groot genoeg is dat VSA by ons kom pleit om ‘n groen kaart te vat en hoofkantoor daar te gaan bou nie.* (GL, MD, radar group, 25 August 2016)
- Translated version of above Afrikaans quotation: *I receive innovation enquiries on a daily basis. Large firms wanting to do new things in new ways – who have problems that they want to resolve. The opportunities are huge, and the time is scarce, but the reason why it is MUCH MUCH MUCH easier to build a Microsoft in the USA than in South Africa, is not that we lack the recipe, or that we do not know how to approach, plan and do it. It is as if the environment and culture around us is 100% against us. It is as if the environment is trying everything in its power to prevent technological success in SA. The only reason why I and others are still wrestling forward – and we are growing faily well – is that we are not big enough yet for the USA to beg us to get a green card and to go and build and set up head office there.* (GL, MD, radar group, 25 August 2016)

4.11.2.5. Success orientation based on technology readiness levels

Reflections in Chapter 3 on technology innovation success revealed a shift towards not only measuring new technology outputs, but also their implementation, adoption and impact. The process of establishing an appropriate suite of measurable impact indicators, their format and their measurement would necessitate discussions beyond the scope of this study.

Instead, this study initially used the NASA (2013) technology readiness levels (TRLs) discussed in Chapter 3 and shown in Figure 3.31 to indicate the level of maturity that a technology has reached in terms of its implementation readiness for adoption by the intended users of technology. The target population is familiar with this practice which may explain why experts supported the use of TRLs to indicate success orientation, as presented in the pilot survey questionnaire in Appendix H.

Despite its virtues, however, the NASA TRLs do not make provision for technology adoption or implementation. For this reason, a tenth level was added to the pilot survey questionnaire for respondents to indicate to what extent technology innovation success had been achieved and to test whether the inclusion of a tenth level would be sufficient as success indicator. The pilot survey results for success orientation, however, did not reveal any salient discriminatory patterns and the research data was further interrogated, as discussed next.

4.11.2.6. Review and adjustment of technology innovation success metrics

While a tenth TRL was added by the researcher to indicate technology adoption, an analysis of the research data and peer feedback during the pilot study raised the following concerns:

- Requesting a respondent to select one level, restricts the respondent to one technology innovation.
- The selection of a TRL under TRL10 may be interpreted as a progress indicator rather than a success indicator.
- A respondent that has accomplished more than one technology may be uncertain as to which one to include in the rating.
- The TRL represents an incremental progress continuum rather than success.

A review of literature did not yield a more appropriate measure, but revealed the following perspectives:

- A better understanding of innovation requires a better understanding of the reasons for success and theory can contribute by enabling the identification and evaluation of these reasons (Smith, 2010:68).
- Success may be leaders shaping innovation performance; innovation leadership is required for the United Kingdom (UK) to remain competitive (Baker, 2003).
- Successful innovation favours organisations that mobilise knowledge and technological skills and experience to create novelty in offerings and ways in which they create and deliver those offerings (Tidd & Bessant, 2013:5).
- Disappointing innovation performances can be because of managers not fully appreciating or understanding the range of things they need to control and do right to be successful (Christensen, 2004).

An alternative success measure was thus compiled to replace the NASA TRL metric in the measurement instrument. The revised success measure question requested respondents to indicate the level to which each of the following descriptors represented what they regarded as successful technology innovation. This construct was described as success orientation based on the term “career success orientation” used in an information technology environment to mean “being able to live out the subjective and personal values that one believes in, as well as the success of the contribution one makes” in a changing world (Havran, Visser & Crous, 2003).

Literature reviews revealed that technology innovation success tends to be measured in terms of technical, business and/or people improvement as applied by the Integrated Innovation Institute at Carnegie Mellon University (High, 2014). Sub-measures were derived from policy and strategy level documents discussed in Chapter 1 (Nizeyimana, 2013; NRF, 2011).

4.11.2.7. Updated measurement instrument

Considering the high statistical values achieved across variables during the pilot study, the main survey items remained unchanged, except for the changes in success metrics discussed above. The final measurement instrument appears as Appendix I to this thesis. The pilot study results provided sufficient grounds to proceed with the study.

4.11.3. Hypothesised model

The hypotheses in this study was generated after completion of the qualitative research phase when constructs and items for inclusion in the measurement instrument were understood and defined (Babbie & Mouton, 2008: 454).

4.11.3.1. Considerations regarding hypothesis formulation

A hypothesis reflects a tentative assumption about the relationship between two or more things that needs to be examined (Welman *et al.,* 2012:12). Hypotheses, whether formulated before or after the observation of empirical data, cannot be proved in any absolute sense and the acceptance of a hypothesis is a function of the extent to which it has been tested and not disconfirmed (Babbie & Mouton, 2008: 454).

Babbie and Mouton (2008:79) emphasised that social research, such as this study, may serve multiple purposes of which the most common purposes are exploration, description and explanation. The authors explained that any given study could have more than one of these purposes in mind and that each would have different implications for other aspects of the research design. This study applied exploration as a first purpose to identify technology innovation leader competencies deemed to be required for successful technology innovation. The measurement instrument developed for the quantitative second research phase pursued a descriptive purpose. An explanatory purpose is reflected in the hypothesis formulation and testing to provide research data, as a basis for theory development.

4.11.3.2. Hypothesised model variables

Dependent variables in the hypotheses were the constructs from the qualitative first phase of the study, while the independent variable was success orientation as an attribute-independent variable. The independent variable was not altered during the study, but the relationships between the independent variable and different dependent variables were investigated, since the former is deemed to have a causal influence on the latter (Bryman & Bell, 2011: 42).

A concept can be seen as an abstraction that represents an object, a property or a certain phenomenon. Concepts form the building blocks of a theoretical model. A construct is a deliberately-created abstract concept that represents a collection of concrete forms of behaviour and such "...concrete behaviours thus qualify as indicators of the construct" (Welman, Kruger & Mitchell, 2012:20-21). A construct may not have a self-evident meaning "...but is deliberately conceived to represent a divergent collection of concrete behaviours" (Welman *et al.,* 2005: 20-21).

Quinlan (2011:109) stated that all of the key concepts in a research project should be included in the conceptual model and that:

> *...there will be many other key concepts which are relevant to the research project and many too of keen interest to the researcher, but the fact that they are excluded from the conceptual model means that they are not part of the research project, and so they are of no concern to the researcher in their engagement with this particular project.*

The hypothesised model for the study of technology innovation leader competencies, deemed to be required for successful technology innovation, incorporated the dependent variables derived from the constructs identified during the qualitative first research phase.

i) Independent variable: Success orientation

ii) Dependent variables:

- Dependent variable one: Being connected with the evolving technology innovation, 'techno-connectedness' (TC).
- Dependent variable two: Stakeholder alignment (SHA)
- Dependent variable three: Liberating mindsets (LMS)
- Dependent variable four: Facilitating value creation (VC)
- Dependent variable five: Facilitating value realisation (VR)
- Dependent variable six: Integrative leadership (IL).

4.11.3.3. Hypothetical model and hypotheses

The hypothetical model in Figure 4.11 conveys multivariate relationship logic of success orientation as independent variable, with an assumed relationship with integrative leadership as a test variable and its underpinning behaviours, with its assumed causal relationship with the other constructs (Babbie & Mouton, 2008: 445).

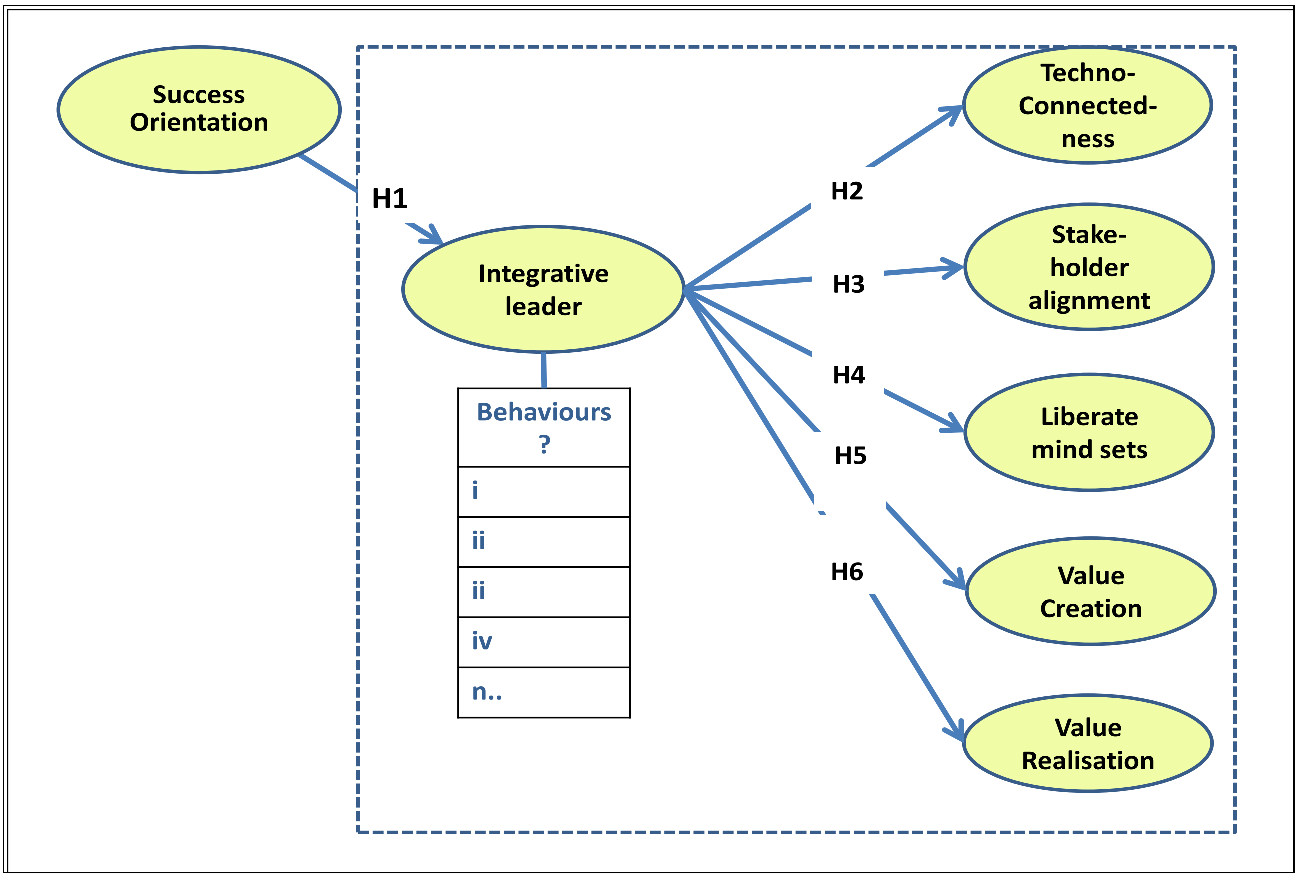


Figure 4.11: Hypothetical model depicting relationship between success orientation and technology innovation leader competences required for successful technology innovation

Hypothesis 1: The success orientation of a technology innovation leader has a relationship with the integrative leadership of a technology innovation leader.

Hypothesis 2: The integrative leadership of a technology innovation leader has a relationship with the technology connectedness competencies of a technology innovation leader.

Hypothesis 3: The integrative leadership of a technology innovation leader has a relationship with the stakeholder alignment competencies of a technology innovation leader.

Hypothesis 4: The integrative leadership of a technology innovation leader has a relationship with the liberating mindsets competencies of a technology innovation leader.

Hypothesis 5: The integrative leadership of a technology innovation leader has a relationship with the value creation competencies of a technology innovation leader.

Hypothesis 6: The integrative leadership of a technology innovation leader has a relationship with the value realisation competencies of a technology innovation leader.

4.11.3.4. Hypothesis testing

Hypotheses were considered based on propositions, claims or statements that may be judged as true or false based on observable phenomena (Blumberg, Cooper & Schindler, 2011). The phenomena to be tested were in the form of tentative assumed correlations between variables that had to be tested through research (Zikmund, 2013).

Testing of the hypotheses included t-tests to test the differences or variance in the means in groups (Quinlan, 2011:401). The exploratory nature of this study and the hypotheses involving more than two variables, necessitated a multivariate analysis (Welman *et al.,* 2012:231). This was introduced in the form of structural equation modelling (SEM) analysis using a partial least squares (PLS) technique, commonly referred to as PLS-SEM (Hair Jr, Hult, Ringle & Sarstedt, 2017: xiii).

4.11.4. Sampling considerations

The research goal is the development of a competency profile for technology innovation leaders in knowledge-intensive organisations in South Africa. The achievement of this goal presupposes gaining access to those people who fall within the target population and soliciting their opinions based on their exposure to innovation leaders and their competencies.

A major research source for this study was the work by De Jong and Den Hartog (2007:42) who also investigated innovation leadership behaviours and had chosen knowledge-intensive organisations for the following reasons. Such organisations employ knowledge-intensive employees like engineering, IT, architecture, consultancy and market research. Such firms constitute a growing share of the business population and add significantly to economic development. Compared to other sectors, knowledge-intensive services have an intangible, heterogeneous and perishable nature and a strong need for continuous minor improvements and additions to their current product offerings, making employees' innovative behaviour very important. Knowledge-intensive organisations are those where the knowledge to perform work is stored in the minds of employees (Van Staden & Du Toit, 2010).

The knowledge epistemology distinguishes between (i) tacit knowledge, which is highly subjective, idiosyncratic and deeply rooted on personal experiences, and (ii) explicit knowledge which is objective and can be untied from the situation by which it was acquired. This knowledge is related to the rational, theoretical, and scientific activities in a positivistic sense (Technovation, 2014).

4.11.4.1. Population

Various institutions have assumed the number of scientists in South Africa as listed in Table 4.14, for their reporting purposes. Other than these assumed numbers of scientists, no credible source could be found to estimate the population of technology innovation leaders who have led one or more teams to successful technology innovation. The sections that follow outline compensating measures applied in this study.

The National Industry Policy Framework (NIPF) prioritises key sectors where government intervention is deemed necessary to eliminate growth and employment constraints (NACI, 2013:40). One of the action plans adopted for the scaling up and broadening of interventions in sectors prioritised since 2007, focuses mainly on manufacturing and ranges from low technology-intensive industries (agro processing, clothing and textiles, paper printing, wood and furniture), to medium technology-intensive industries (motor vehicles, plastics, fabricated metal products and rail transport equipment) to high technology-intensive pharmaceutical industries. Formal employment in these sectors is shown in Table 4.13 below.

Table 4.13: Formal employment in technology-intensive industries

Industry	2005	2008	2011
High-technology	38 429	41 861	44 676
Medium high-technology	340 570	359 046	329 491
Medium low-technology	383 269	387 154	402 618
Low-technology	673 560	556 109	527 804
Total	**1 435 828**	**1 344 170**	**1 304 589**

Source: NACI, 2013:40.

While the numbers of formal employees reported in Table 4.13 can be assumed to be accurate and credible, it does not indicate the number of technology innovation leaders employed, which would render the use of probability sampling impossible or extremely difficult. The time and costs involved in attempting to apply a probability sample would be the second reason for selecting a non-probability sample (Bryman & Bell, 2011:170). It would thus be inappropriate to apply the above numbers mechanistically in any sampling exercise involving technology innovation leaders.

4.11.4.2. NSI population

Successful technology innovation leaders were not specifically identified, recorded or published in publicly available sources and the assumption was therefore made that potential survey participants were likely to be included in the researcher population shown in Table 4.14.

The 2014/15 National Survey of Research and Experimental Development reported significant recent increases in the number of R&D personnel in South Africa to reach 38 465, including all persons employed directly on R&D activities, and those providing direct services such as R&D managers, administrators and clerical staff, as well as postdoctoral students (HSRC, 2017: ix, 26). The assumed population of researchers would thus be between 20 994 and 38 465 and the actual numbers would fluctuate depending on the inclusion or exclusion of students and support staff, as well as the nature of their employment.

Table 4.14: Researchers in South Africa: 2007 or more recent year available

Researchers in South Africa	2010	Descriptor	2015 estimate
South African population	50.9 million (World Bank)	52.98 million in 2013 (World Bank)	54.96 million (StatsSA, P0302, 2016)
Total number of researchers (FTE)	18 574	Universe (100%)	20 994
Share of women (%)	7 374	39.7%	-
Researchers per million inhabitants (FTE)	382		382
Technicians per million inhabitants (FTE)	130		-
Researchers in business enterprises sector	6 111	32.9%	6 907
Researchers in government sector	2 768	14.9%	3 128
Researchers in higher education sector	9 481	51%	10 700
Researchers in private non-profit sector	204	1%	210
CSIR headcount	2 400	100%	-
SET (science, engineering and technology) professionals	1 564	65.1%	-
Executive leadership	24	0.1%	-
SET (science, engineering and technology) leadership	77	4.92%	1 033
Successful technology innovation leaders	Unpublished	Unpublished	Unpublished

Source: Adapted from UNESCO, 2010: 284; *Mail & Guardian*, 2012, StatsSA, 2016.

While it was assumed that potential survey participants would be included in the NSI population, the researcher still had to identify successful technology innovation leaders in this population before survey invitations could be directed to selected individuals.

4.11.4.3. Sampling frame

A sample frame provides a means for choosing particular population members for a survey sample and is determined by two questions, namely: “Who needs to be studied to answer the research question?” and “How to get access to a sampling frame?” (Bryman & Bell, 2011:86).

The research question is: “What technology innovation leader competencies are deemed to be required for successful technology innovation?” The target group for answering the research question comprised of people with current or previous responsibility for technology innovation at knowledge-intensive organisations in South Africa, such as innovation-inspired technology enterprises, research and innovation laboratories, science councils, universities and technology-based joint ventures.

Ideal respondents would meet the following criteria: They would

- serve or have served in a management or leadership position responsible for technology innovation,
- in a knowledge intensive organisation in South Africa,
- with previous success in leading others through technology innovation across the full process from the identification of a problem, challenge or opportunity, through to value realisation.

4.11.4.4. Access to sampling frame

Demographic and performance-related information, such as personal details of the target group, is no longer available in the public domain. The Protection of Personal Information Act (PoPI) became law on 26 November 2013 in South Africa (RSA, 2013). PoPI regulates how anyone who processes personal information must handle, keep and secure such information. Institutional repositories of personal information would not disclose personal information about their employees. Secondary sources had to be relied upon for this study, resulting in most of the following sources demanding that invitations for research participation be conveyed through them to members who would make available their email details if interested. Table 4.15 shows institutions where nodal individuals supported this research, and informed their members about the study and encouraged their participation.

Table 4.15: Sources of email details of eligible research participants

Sources	Remarks
SARIMA: South African Research and Innovation Management Association	Members from academic, government, business research and innovation managemnent, and technology transfer professionals
SAINE: The South African Innovation Network	Members from government, academia, industry, and society networking to enhance innovation
NSTF: National Science and Technology Forum	Research and innovation excellence focus
NRF: National Research Foundation	SARChI: South African Research Chairs Initiative
Innovation Summit	Annual summit attracting international participation and entrepreneurial interest groups
SID: Stellenbosch Innovation District	Hosted innovation conferences with the Executive Mayor’s Office
Innovation Hub	Gauteng Province focus
DST: Department of Science and Technology	SARChI: South African Research Chairs Initiative and Centres of Excellence
NACI: National Advisory Council on Innovation	Innovation policy monitoring and advice
Launchlab, incubators, Netprophet and related initiatives.	Technology entrepreneurs focus

4.11.4.5. Sampling strategy, process and method

The use of a probability sampling where every unit in the population has a known chance of being selected would allow for representative sampling if all information about units had been available. However, this was not achievable due to the PoPI legislation (RSA, 2013b) mentioned before.

The targeted individuals for this study do not all work for the same organisation and may not share common descriptive demographics. Such individuals may be found across the NSI of South Africa and may be found in different organisations, disciplines and sectors of the economy where technology innovation is pursued.

Another factor taken into account was the emergence of innovation as a profession for which professional membership and development structures are still being developed. The pool of respondents would thus be made up of people with responsibility, institutional employment and professional association that are not mutually exclusive, since a particular respondent may belong to more than one of these evolving groupings.

Consequently, the researcher adopted snowball sampling as an appropriate sampling strategy for this study. Snowball sampling is a form of convenience sampling where "the researcher makes initial contact with a small group of people who are relevant to the research topic and then uses these to establish contacts with others" (Bryman & Bell, 2011:192).

4.11.4.6. Snowball sampling

The snowball sampling process was initiated by the researcher who sent out SMS messages to 432 cell phone numbers of personal contacts who had been identified by the researcher as individuals who may qualify as eligible respondents and/or would be able to direct the invitation to eligible respondents. SMS recipients were selected by the researcher based on their involvement with technology innovation, including executives, human resource managers, "champions of industry" (OECD, 2009:191) and members of LinkedIn professional networks.

The following message was sent to all SMS recipients in batches of up to 50 between 1 and 27 June 2016:

> *Awie Vlok kindly requests your help to locate leaders at SA organisations whose team(s) achieved technology innovation(s), for his PhD research. Please send email details of eligible candidates (you and others you know?) to avlok@sun.ac.za or via return SMS. I will send more information and the link to a 20-minute confidential survey to rate the significance of identified leader competencies. Final results will be shared with interested respondents. Thank you, Awie.*

The SMS message resulted in SMS and email responses to the researcher that were not recorded or analysed because of the logistics involved, but were generally supportive or informative in terms of respondents indicating that they would forward the request to others in their networks. From the responses received the researcher compiled a list of 5 715 email addresses to which survey invitations were sent by the survey administrator.

4.11.4.7. Sampling bias

A sampling bias is a distortion in the representativeness of samples that occurs when some members in a sampling frame stand little or no chance of being selected for inclusion in the sample (Bryman & Bell, 2011). This study sent email invitations out in 12 batches over nearly sixteen weeks, between 1 June 2016 and 30 September 2016, and all responses received between 1 June 2016 and 3 October 2016 were captured.

During the school holidays, up to 40 percent of invitations bounced back for reasons that included being overseas, on vacation, absent or away. The sending of three reminder messages to non-respondents allowed all an equal chance of being included if they had been nominated by anyone in the snowball sampling process.

4.11.4.8. Confirmation of respondent eligibility

Care was taken in correspondence during the survey phase of the study to ensure that respondents confirmed their eligibility in the measurement instrument so that only technology innovation leaders meeting the criteria would submit their completed responses. Examples of messages used in correspondence, as well as the survey questionnaire appear in Appendix J.

Knowledge generation and knowledge application activities may be concentrated in one or more job descriptions or organisational structures found at universities and some science councils.

By allowing invitees to confirm their eligibility in the measurement instrument, it was envisaged that only leaders who have experienced successful technology innovation would be those indicated in Figure 4.12.

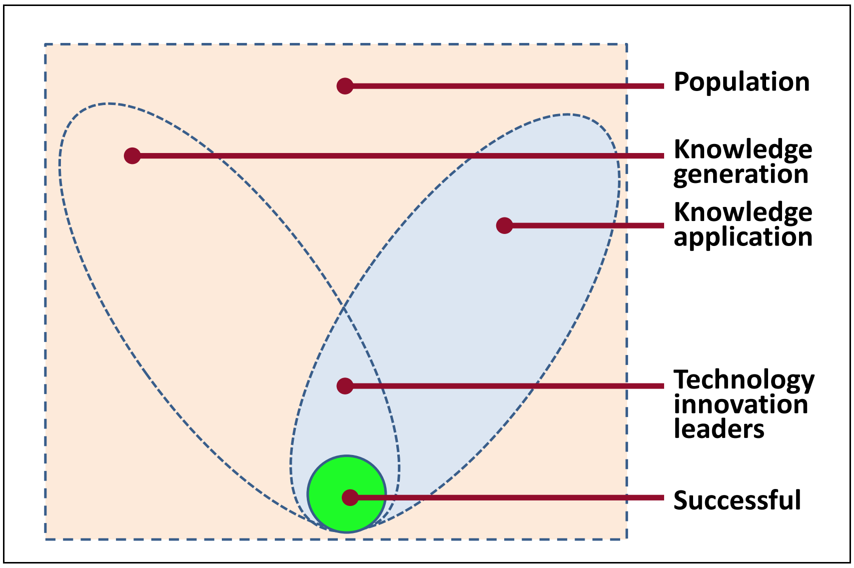


Figure 4.12: Sampling strategy

4.11.5. Anticipated research challenges

Measuring innovation as a creativity-related phenomenon may present measurement challenges. According to Amabile (1996:3), science is "the study of observable phenomena" and "involves the shaping of observable behaviours and outcomes", suggesting that any assessment of creativity must be based on observable products or manifested ideas. While a highly-creative person might create a highly-creative thought process, assessment can only be based on what is observable. Amabile (1996) bridged this challenge by proposing consensual assessment as method. This means that experts, or at least people who are familiar with the domain, apply their own subjective view of innovation and make completely independent judgments on the domain that may "produce judgments that inter-correlate surprisingly well" (Amabile, 1996:4).

> *The guiding assumption is that, in recognising creativity in a particular domain, people who actually work in that domain know best. As long as there is a good degree of agreement in the independent judgments made by experts (and there usually is), then composites of their ratings can be used as the creativity measures. The consensual assessment technique may not be useful for truly break-through work in many domains, but then, no assessment method is useful for work being done at the frontiers of a domain; only the test of time and historical consensus can say whether work was truly creative or merely bizarre. Moreover, the consensual assessment technique allows us to measure something as inherently unpredictable as creativity by allowing us to avoid specifying particular criteria in advance. We cannot say exactly what characteristics the next creative breakthrough in biochemistry will have, but we are confident that, in time, biochemists will reliably recognise it as such.* (Amabile, 1996:4)

Non-response and refusal of eligible invitees to participate may also present challenges because of "over-surveying" (Mouton, 2003:106). Challenges not identified by Mouton may be more recent introductions to research protocols observed by the researcher, such as invitations not being delivered due to technical, security and ethics requirements. Response rates were monitored and remedial action considered.

4.11.6. Project plan

A project plan was compiled to schedule and review progress of research activities during the quantitative research phase. The project plan allowed the researcher to coordinate work that involved several people, including the researcher, study leaders, research administrator, and professional as well as technical advisory and support staff.

4.11.6.1. Ethical clearance and informed consent

Ethical clearance was granted for obtaining research inputs from experts and practitioners during the qualitative first research phase. The quantitative second research phase adopted a snowball sampling strategy, for which no additional clearance was required. Participants had to, however, express their informed consent, which was covered in the first field of the online questionnaire and particiapants were given the option to opt out at any stage. The development of the measurement instrument is discussed in Section 4.12.2.

All correspondence made reference to the ethical clearance and underlying principles. An ‘opt out’ option was added to the questionnaire and all responses were kept by the survey administrator who only provided the research with Excel spreadsheets that contained the data received from respondents in both the pilot and main surveys.

The University’s ethics committee conditions for this type of survey made participation voluntary, confidential and anonymous. However, provision was made for respondents to share biographical details in Part 1 of the questionnaire on a voluntary basis.

Interviews with experts were conducted in accordance with the ethical clearance guidelines and the names of experts who provided inputs, were removed from the thesis.

4.11.6.2. Data collection

Data collection during the quantitative second phase of this study was done in the form of a web-based questionnaire or measurement instrument, which was only accessible through encrypted passwords or similar practices employed by the professional research questionnaire practitioners recommended by dedicated Stellenbosch University officials who operate within the governance and ethics policies of the University. All data from the survey was taken off the questionnaire server when the study was concluded to avoid further unauthorised access.

The questionnaire captured respondents’ demographics on a voluntary basis, their views on innovation and success, as well as their ratings of the perceived significance of identified leadership behaviours or items listed under each of the technology innovation leadership competencies or constructs that make up the competency profile envisaged in the title of this research study. This study aimed to approach 1 000 eligible respondents. A 20 percent response rate would yield 200 sets of input data which would provide sufficient volume of data for using partial least squares in structured equation modelling (Kline, 2011).

4.11.6.3. Distribution of measurement instrument

The snowball sampling SMS message was also sent to selected personal contacts of the researcher, through the LinkedIn social media platform, as personalised messages. In total, 5 715 email invitations were sent in 12 batches between 1 June 2016 and 30 September 2016. The response rate is discussed in Chapter 6.

4.11.6.4. Survey administration

An experienced survey administrator who is employed by Stellenbosch University was allocated to this study for questionnaire administration and follow-up correspondence with respondents. Survey data flowing from online survey participation by respondents was submitted to the researcher in MS Excel format by the survey administrator approximately once a week between June and September 2016.

4.11.6.5. Data security and integrity

Research data was safeguarded through access control by the survey administrator and the researcher. Research data was kept on the researcher's desktop computer with backups kept on an external hard drive and locked away in a cabinet.

4.11.6.6. Data preparation

Compulsory fields in the survey questionnaire ensured that respondesnts had to answer all questions before their responses would be saved and submitted via the online submission channel provided. As a result, the submissions were complete and assumed to accurately reflect respondents' views.

4.12. SURVEY RESPONSE RATE

Calculation of a response rate is common in social survey research to express the number of usable responses as a percentage of the total sample after unsuitable or uncontactable members of the sample had been deducted (Bryman & Bell, 2011:189). Response rates of 18 percent and above have been accepted by leading management journals and low response rates may not be significant when samples are not selected on the basis of probability sampling as was the case in this study (Bryman & Bell, 2011: 236). Approximately every week, the researcher used the MS Excel sheets generated by the survey administrator to monitor response rates as reported in Chapter 6.

4.13. DATA ANALYSIS AND INTERPRETATION

Data analysis in this thesis was guided by the research question, research objectives, as well as theoretical and methodological frameworks presented throughout this study (Quinlan, 2011:5).

While the pilot survey analysis focused on reliability and validity aspects constrained by a relatively small number of respondents, the main survey provided research data from a sufficiently larger number of respondents that allowed for the use of structural equation modelling. Structural equation modelling (SEM) is a class of multivariate techniques that combines aspects of factor analysis and regression that enables the researcher to simultaneously examine relationships among measured variables and latent variables, as well as between latent variables for assessment of measurement theory and assessment of structural theory in the latter two cases respectively (Hair *et al.* 2017:1).

Structural equation modelling (SEM) analysis using a partial least squares (PLS) technique commonly referred to as PLS-SEM involves prediction from a set of dependent relationships simultaneously, beyond what first-generation statistical methods, such as factor analysis and regression analysis, were designed to provide (Hair *et al.* 2017:1).

Statistical analysis has been used for more than a century by social science researchers who relied on uni-variate and bi-variate analyses to understand data and relationships, while newer multivariate analysis involves the application of statistical methods that allow for better understanding of more complex relationships through simultaneous analysis of multiple variables (Hair *et al.* 2017:2).

Hair *et al.* (2017:2) regard PLS-SEM as one of only two methods that can be classified as second-generation multivariate techniques and PLS is favoured for exploratory research aimed at theory development because it focuses on explaining the variance in the dependent variables when examining the theoretical model. The exploratory nature of this study thus justifies the use of reflective PLS-SEM rather than covariance-based SEM (CB-SEM) that Hair *et al.* (2017:2) recommend for confirmatory studies with strict compliance criteria regarding theoretical foundations and the use of data to confirm or reject theories based on how well a theoretical model can estimate covariance.

Table 4.16 provides a summary of first and second generation multivariate methods (Hair *et al.,* 2017: 2).

Table 4.16: First and second generations of multivariate methods

Generation	Primarily exploratory	Primarily confirmatory
First	• Cluster analysis • Exploratory factor analysis • Multidimensional scaling	• Analysis of variance • Logistic regression • Multiple regression • Confirmatory factor analysis
Second	• Partial least squares structural equation modelling (PLS-SEM)	• Covariance-based structural equation modelling (CB-SEM)

Source: Adapted from Hair Jr, Hult, Ringle and Sarstedt, 2017: 2.

The preceding discussion justifies the use of second generation multivariate methods instead of traditional first generation multivariate methods for data analysis for the main survey.

4.13.1. Pilot survey analysis

Quantitative research data received from the survey administrator in MS Excel format was processed and analysed in collaboration with professional statisticians. This aided the researcher in gaining insight into the composition of the sample and establishing the strength of relations between the identified constructs and variables, while meeting the validity, reliability and technique-specific requirements associated with scientific research during the pilot study. Results are discussed in Chapter 6.

4.13.2. Main survey data analysis and interpretation

Quantitative research data from the main survey was analysed by using descriptive statistics and inferential statistics, as discussed in Chapter 6. All variables were subjected to tests to determine relationship correlations that in nearly all cases were found to be positive and significant as indicated in the tables and graphics to follow. STATISTICA software was used for the initial analysis as was done in the pilot study when sample data came from 52 respondents that limited the modelling options that became available with 266 respondents (Hair Jr *et al.,* 2017).

Descriptive statistics are used to describe the data gathered and may be presented, such as summarising statistics where each variable can be described in several ways, including most generally-used statistical indicators like frequencies, ranges, means, modes, medians and standard deviations (Quinlan, 2011: 399).

Inferential statistics are used by the researcher to reach conclusions that extend beyond the data to infer, based on the study of a sample of a population, what the entire population might think or do (Quinlan, 2011: 399). This study involved the examination of data collected from a sample drawn from a larger population to make assertions about the larger population by making inferences on a logical basis (Babbie & Mouton, 2008). Inferential statistics were used to relate results to the research questions and test the hypothesised relationships between variables.

The interpretation of statistical results in Chapter 6 focused on salient trends and patterns based on the statistical significance of observed relationships in the following context: "…there is no scientific answer to the question of whether a given association between two variables is significant, strong, important, interesting or worth reporting ... the ultimate test of significance rests with your ability to persuade your audience" (Babbie & Mouton, 2008:476).

4.13.3. Sample demographics

Descriptive statistics entail techniques for organising, summarising, graphing and presenting quantitative information (Cramer & Howitt, 2004). In this study, descriptive statistics were used to gain insight into the composition of the sample in terms of its demographics. The main survey results obtained are presented as graphs, tables or other figures to convey the salient observations on the sample profile and shape, location and spread of data regarding the measured demographic respondent variables.

4.13.4. Psychometric properties

The psychometric properties of the newly-developed measurement instrument were assessed during the pilot survey, as well as the main survey to enhance confidence in the instrument for identifying technology innovation leader competencies deemed to be required for successful technology innovation. According to Bryman and Bell (2011: 169), reliability testing and validity testing are often put forward as ideals in research, but writers rarely report tests of the stability of their measures (reliability) and even more rarely report evidence of validity.

The reliability of the instrument refers to the consistency of a measure or a concept, in other words, whether respondents' scores on any one indicator tend to be related to their scores on other indicators (Bryman & Bell, 2011: 158). Reliability analysis of constructs are reported and discussed in the pilot survey results section of this chapter and main survey results are reported in Chapter 6.

The validity of the instrument refers to whether an indicator or set of indicators derived to gauge a concept, really measures that concept. Validity was measured in this study through the following types of measurement validity (Bryman & Bell, 2011:159):

- Content validity represents a theoretical judgement about whether the test items theoretically reflect the construct. Experts confirmed, before the pilot survey, that the questionnaire indicators represented the domain of the latent concept under research (Hair Jr *et al.,* 2017:49).
- Face validity tests if a measure apparently reflects the content of the concept in question and may be established by asking people with experience whether or not, on the face of it, the measure reflects the concept concerned. Respondent feedback obtained during the pilot survey ensured that the respondents viewed the test as a legitimate test.
- Construct validity indicates the relationship between constructs in a theoretical model of hypothesis and is reported in the pilot survey section and Chapter 6.

Bryman and Bell (2011:160,161) asserted that, despite multiple ways being available for investigating measures that are devised to represent social concepts, not all new measures of concepts are submitted to scientific rigour. Bryman and Bell (2011: 160) advised researchers to take "fairly straightforward but minimal steps" to ensure that a measure is reliable and/or valid, such as testing for internal reliability when multi-indicator measures are devised and examining validity. These steps were indeed followed and results reported in the pilot survey section and for the main survey in Chapter 6.

4.13.5. Reliability of constructs

The measurement instrument showed high reliability during the pilot survey as reported in the pilot survey section. For the main survey, the measurement instrument was again subjected to reliability testing and the results are presented in Chapter 6. The reliability analysis for each construct is also presented in Chapter 6.

4.13.6. Two-dimensional scatterplots

Two-dimensional scatterplots were mapped to indicate the values of r, P, Spearman r and Spearman p for all construct intersections. Determining the strength of a relationship between two variables is based on the size of the Pearson correlation (r) which ranges from minus 1.00 to 1.00. Cohen (1988, cited in Pallant, 2001) suggested that r values of 0.10 to 0.29 be regarded as small, 0.30 to 0.49 as medium and 0.50 to 1 as high.

4.13.7. Summary of correlations

A summary of Spearman correlations is presented in Chapter 6.

4.13.8. Evaluation of measurement model fit

The measurement model fit is an indication of the degree to which the model is consistent with empirical data and was analysed by considering the following indicators (Hair Jr *et al.,* 2017):

- Internal consistency;
- Outer loadings;
- Composite reliability;
- Average variance extracted (AVE); and
- Discriminant validity

Discriminant validity is the extent to which one variable or construct is truly distinct from others and can be assessed using the Fornell-Larcker criterion, the cross-loadings or Heterotrait-monotrait (HTMT) ratio of between-trait correlations to the within-trait correlations (Hair Jr *et al.,* 2017:118), as presented in Chapter 6.

A nomological network represents the constructs of interest in a study, their observable manifestations, and the interrelationships among and between these, by linking the conceptual or theoretical realm with the observable realm as a central concern of construct validity (Trochim, 2006:1). However, Trochim (2006) indicated that, while a nomological network may provide a philosophical foundation for construct validity, it fails to provide a practical and usable methodology for assessing construct validity.

Trochim (2006) proposed the multi-trait-multi-method matrix as a more appropriate methodological approach to construct validity because it allows for adding a new construct or relation to a theory that generates laws (nomologicals) confirmed by observation or reduces the number of nomologicals required to predict some observables. In this study, the Heterotrait-Monotrait ratios were determined and are presented in Chapter 6.

4.13.9. Assessing PLS-SEM structural inner model results

The construct measures were described in the preceding sections, the assessment of the PLS-SEM results is discussed next, based on a systematic approach derived from Hair Jr *et al.* (2017:190):

In structural models that include collinearity, a collinearity assessment is done to prevent possible path coefficient bias if estimation involves critical levels of collinearity among predictor constructs, which is not the case in this study. This study model is assessed in terms of “how well it predicts endogenous variables/constructs” (Hair Jr *et al.,* 2017:192). Rather than assessing goodness-of-fit, the structural model is primarily assessed on the basis of heuristic criteria as determined by the model’s predictive capabilities by assessing how well it predicts the endogenous variables or constructs contained in the remaining steps (Hair Jr *et al.,* 2017:191). The tables compiled from analysed research data are presented and discussed in Chapter 6, including the following values that are suggested for their added value in assessing PLS-SEM inner models (Hair Jr *et al.,* 2017:196):

- *t* values;
- *p* values;
- Multi-colinearity;
- Path coeffients in the structural model;
- Coefficients of determination (R^2 values);
- Hypotheses test results as a statistical model; and
- The f^2 effect size

4.13.10. Researcher reflections on statistical results

Following the presentation and discussion of the quantitative research results in Chapter 6, the researcher reviewed and summarised salient observations from the findings and analyses presented as summarised in Table 6.24 in a tabular format.

4.14. THEORY DEVELOPMENT

As discussed in Chapter 3, it is important for theory development in this study to bridge the gulf between grand theory and research findings by considering theories that, according to Bryman and Bell (2011:9), seek to “...understand and explain a limited aspect of social life” and according to Malhotra (2015) describe a set of statements or principles devised to explain a group of facts or phenomena that can be used to make predictions about natural phenomena. While ‘theory’ is an explanation of observed regularities to explain a phenomenon, ‘grand theory’ offers a “theoretical perspective” characterised by a high level of abstraction in relation to research findings (Bryman & Bell, 2011:8).

Section 5.5 proposes emerging elements of a technology innovation leadership theory that were subjected to testing in Chapter 6. Chapter 6 provides and analyses the research data resulting from the quantitative research phase to contribute to the understanding of the measured aspects and describe a set of statements or principles to explain groups of facts that can be used to make predictions about the technology innovation leader competencies deemed to be required for successful technology innovation.

4.15. COMPETENCY PROFILE

Chapter 3 defined a competency profile as a description of the required competencies in sufficient detail for competency gaps to be assessed and addressed through human capital development programmes (Kaplan & Norton, 2004:225).

When the concept of "a competency profile for technology innovation leaders..." was proposed in the 2011 research proposal for this research, no prior scholarly reference to the term could be found. In November 2015, the researcher received an invitation to attend an innovation leadership programme during 2016, hosted by Cambridge University, in which the facilitator, Professor Victor Newman (2015), claimed that competency descriptions should be available in a practical form that could help leaders and organisations to change.

According to Newman (2015:1):

> *Most people have no idea what their innovation leadership profile looks like. They are in effect, blind leaders of innovation. Not being in control of your own innovation leadership behaviours is like leading your team or organisation as though it is a car that you drive with a blindfold.*

It is argued therefore, that the term "a competency profile for technology innovation leaders..." has entered the scholarly body of knowledge and rather than justifying the existence of the term, this thesis aims to contribute to the understanding of the term.

4.16. THE RESEARCH THESIS

Upon completion of both the qualitative and quantitative research phases of this study, this research thesis was compiled for reporting and assessment purposes as per institutional requirements and agreements entered into by the researcher.

A research thesis is the final embodiment of the research project and documents the thinking, decisions, and reconstruction of the research logic, "i.e. the principles of reasoning, of the research thesis is the logic of *validation*" which includes "...the act of advancing and clarifying arguments, reasons and evidence for reaching certain conclusions" (Mouton, 2003:113). Mouton (2003:113-114) proposed three rules of scientific evidence, namely that evidence should be objective, appropriate and "...strong enough to support the conclusions that are drawn from it".

While Chapter 4 explained and justified the research design and methodology for this study, Chapter 5 provides and discusses the research evidence from the qualitative research phase, and Chapter 6 offers research evidence from the quantitative research phase. Chapter 7 serves to summarise, integrate and conclude this study.

4.17. MAINTAINING GOOD RESEARCH PRACTICE IN QUANTITATIVE PHASE

Adherence to good research practices during the qualitative research phase was reported in Section 4.11, as per Research Objective 4 in Section 4.1.

In the quantitative research phase, good research practices were adhered to through the application of partial least squares structural equation modelling (PLS-SEM) approaches and data analysis, by using the embedded functionalities of the SmartPLS-software, in support of the expressed objectives.

4.18. CHAPTER CONCLUSION AND SYNTHESIS

This chapter provided clarity on the research design and methodology as well as the planning that was done prior to implementing the research to identify technology innovation leader competencies deemed to be required for successful technology innovation, which was the main aim of this study.

The provisional conceptual model and updated conceptual model as well as theoretical framework developed from the literature review, confimed the research problem and main research question. These were used to justify the adoption of anti-positivist, positivist, and pragamatic research philosophies and the use of a sequential exploratory research design, made up of a qualitative phase and a quantitative phase.

The qualitative research would capture research data from experts, cases, workshops and and use content analysis to analyse data for the development of construct and items for inclusion in the development of a measurement instrument. During a pilot workshop, a validated measurement instrument was used to obtain research data for the formulation of a hypothesised model. A main survey involving respondents identified through peer-referenced snowball sampling yielded research data for performing reflective partial least squares structural equation modelling, which is used for theory development.

Following ethics approval, a survey administrator from another department was appointed to distribute the measurement instrument and capture survey data that was made available to the researcher in a spreadsheet format. A research plan was developed for implementation.

The purpose of this chapter was to plan and to provide structure for the research, including the research design and methodological framework, sampling approach and procedural aspects of obtaining and processing research data to address the research question. The next chapter presents and discusses the qualitative research results, followed by the presentation and discussion of the quantitative research results (Bryman & Bell, 2011:681).

CHAPTER 5

QUALITATIVE RESEARCH PHASE RESULTS

5.1. CHAPTER INTRODUCTION

The purpose of this study is to identify technology innovation leader competencies deemed to be required for successful technology innovation. Chapter 4 conveyed the research problem and question, research philosophy, research design and methodology, as well as the data sources selected to pursue the purpose of this study. Accordingly, this chapter presents the results of the qualitative research phase, while the quantitative research phase results are presented in Chapter 6. By applying research themes across research sources as discussed in Chapter 4, this chapter reveals the specific leader behaviours identified and aggregated to form constructs and items for inclusion in the measurement instrument that was subjected to rigorous scrutiny during the quantitative phase of this study.

Figure 5.1 summarises the key elements and messages addressed in this chapter. The iterative nature of the data gathering and processing in this chapter is the reason why the sequencing of elements and messages are differently mapped, compared to other chapter maps in this thesis.

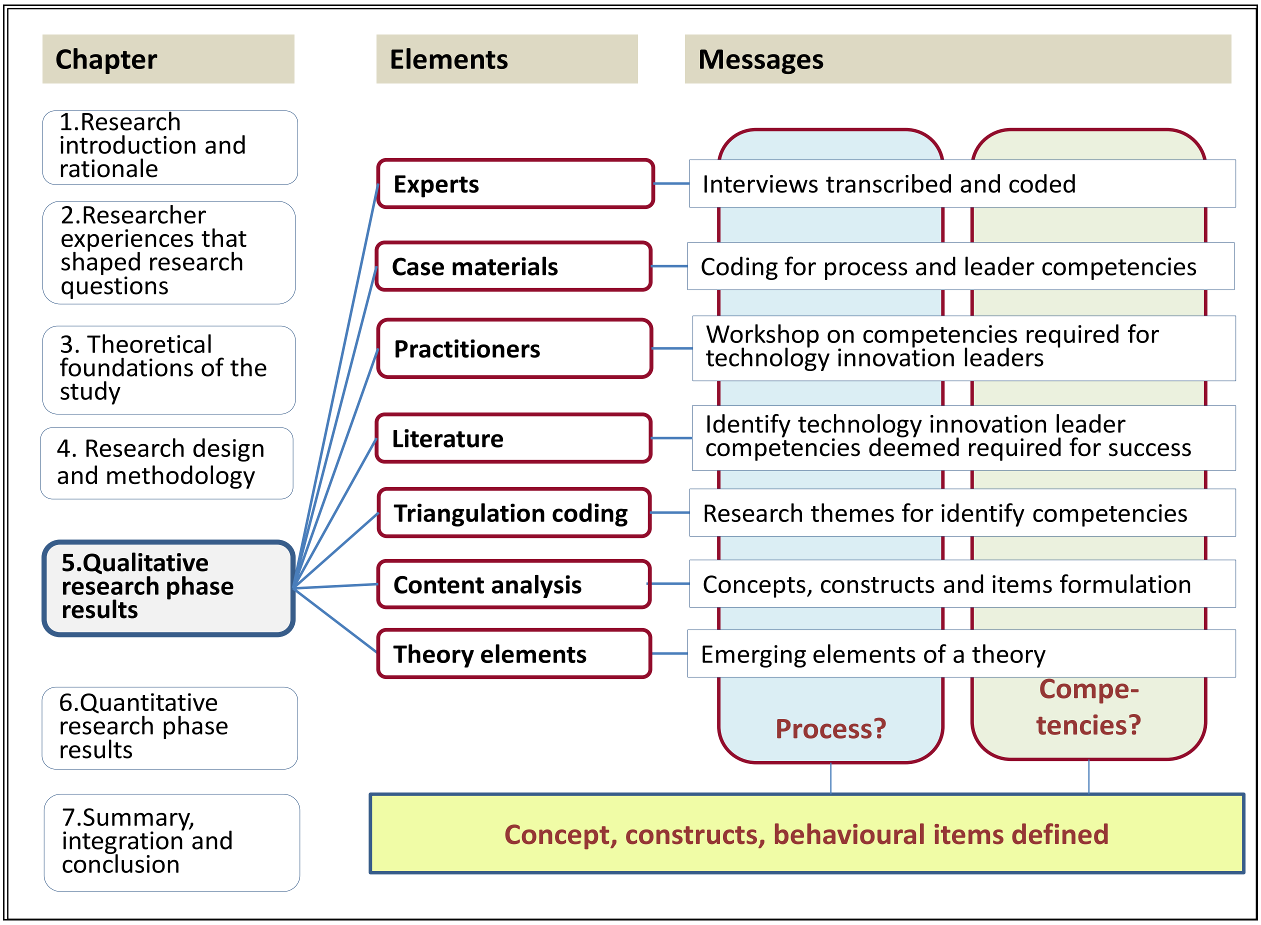


Figure 5.1: Thesis map of Chapter 5

Based on the conceptual model presented in Chapter 1, Figure 5.1 also indicates the dual nature of an empirical framework adopted in this study to focus on both innovation process and leader competencies during the fieldwork to result in findings for the qualitative research, and during the quantitative research of Chapter 6 to provide research results.

The assumed relationships between the process and interim capability clusters presented in the conceptual model in Chapter 1, were treated as propositions until they were included as research sub-questions that became research themes from which constructs could be derived for the measurement instrument and hypotheses posed.

5.2. PROCESS PERSPECTIVES FROM QUALITATIVE RESEARCH SOURCES

Figure 5.1 shows process perspectives as a first research focus followed by leader competencies perspectives, though both were extracted from research sources, as discussed in Chapter 4.

5.2.1. Technology innovation process perspectives from experts

The transcription of a personal interview conducted with Dr Bettina von Stamm, a leading author in innovation management and founding convener of an international forum for innovation executives to exchange learning (Von Stamm, 2013) revealed contemporary perspectives on the changing and dynamic nature of innovation processes, the innovation leader's influences on changing the thinking of those involved in the innovation projects and the role of the technology innovation leader in creating a conducive environment for innovation to flourish.

Opinions of the experts listed in Table 4.7 were recorded, transcribed as shown in Appendix A, and coded for thematic analysis using the 37 codes in Table 5.2. Process codes were also used for the coding of innovation process perspectives from the other qualitative research data, as summarised in Appendix E.

Researcher insights gained from expert opinions about the technology innovation process can be summarised as follows:

- Successful technology innovation leaders tend to use dynamic interactive processes, rather than traditional linear sequential process models, except in cases where some critical path flow is determined by natural, chemical or technical sequence requirements.
- In all cases, experts revealed that the technology innovation processes were context-directed and did not match a standard process model from literature.
- In all cases, technology innovation processes had to be adjusted when changes in the external environment occurred or when internal results did not meet expectations.
- In all cases, technology innovation processes made provision for engaging stakeholders in both direction-setting as well as endorsement activities, in support of technology innovation.

5.2.2. Case analyses of technology innovation processes

The researcher reviewed and analysed the cases that follow, as outlined in Section 4.6.2.

5.2.2.1. Review of Kennedy's speech for process dimensions

The 1961 speech by former President, J.F. Kennedy, entitled *We choose to go to the moon*, was labelled as "a speech that changed the world" (Lowne, 2007:72). The text clearly describes the part of technological innovation that requires stakeholder alignment in support of technology innovation that had not been achieved before. A content analysis of this speech emphasised the codes shown in Appendix E, which supports the notion of stakeholder support being part of successful technology innovation processes (Lowne, 2007). Furthermore, this reinforces the retention of the stakeholder alignment research theme for the identification of leader competencies.

5.2.2.2. Review of Steve Jobs biographic film for process dimensions

The 2013 film entitled *Steve Jobs*, in which some of the technology innovation leader capabilities of the founder and former CEO of Apple Computers are portrayed, and an analysis of process-related technology innovation leadership messages, revealed the development of a compelling technology innovation vision with a team and how the leader facilitated value creation and value realisation aspects of technology innovation. When Steve Jobs returned to Apple he said:

> *…You've got to start with the customer experience and work backwards to the technology. You can't start with the technology and try to figure out where you're going to try to sell it and I've made this mistake probably more than anybody else in this room. …You can't just ask customers what they want and then try to give that to them. By the time you get it built, they'll want something new*. (*Futurelab*, 2014:1)

These views expressed by a successful technology innovation leader were incorporated in the Appendix E summary that shows the codes from Table 3.14 that justify the retention of the research themes of this study for leader competencies identification.

5.2.2.3. Review of CSIR technology innovation cases for process dimensions

An analysis of technology innovation cases from a building technology research and innovation unit (Vlok & Page-Shipp, 2015) supported the expansion of the four-stage innovation process model of Swart (2013), as discussed in Chapter 3. In cases where technology innovation based on the four-stage innovation process model started with idea generation and resulted in new technologies, new technologies had mostly failed to be adopted or implemented. In cases where stakeholder alignment and technology connectedness had been included in the technology innovation process, new technologies had, in the cases observed, resulted in successful adoption or implementation. From these observations it can be argued that the retention of the interim capability clusters or research themes would support the identification of leader competencies, as indicated by the coding reflected in Appendix E.

5.2.2.4. Review of thirty science-derived innovation cases from South Africa for process dimensions

An analysis of 30 South African cases recorded on scientific breakthroughs that resulted in successful technology innovation (Wild, 2015) revealed that, while all cases implied innovation processes resembling at least a four-phase process model, they may not necessarily have occurred in a linear sequential flow. From interpreting the case descriptions, it seems that technology connectedness and stakeholder alignment as interim capabilities (Table 3.14) had also featured in the success of these technology innovations, as indicated in Appendix E.

5.2.3. Practitioners workshop perspectives on technology innovation processes

A bio-economy strategy workshop took place with 34 technology innovation leaders (mostly research group leaders and competency area managers) on 24 November 2014, where the appointment of a new director was on the agenda and the position’s requirements were discussed. Everyone in the session was asked to anonymously write down on a piece of blank paper the technology innovation leader competencies that they, from their personal experience, would associate with successful technology innovation. The consolidated list of competencies compiled from everyone’s inputs is presented in Appendix L and summarised in Table 5.1 according to research themes.

Table 5.1: Technology innovation leader competencies from practitioner workshop

Cluster	Summary of identified competencies
Connected with evolving technology innovation landscape	Familiar with latest technology trends and cutting-edge technology. Have a vision on where technologies are heading and have general knowledge of adjacent fields. Knowledgeable in all fields where the team/unit is focusing. Find and integrate trends in selected fields of endeavour. Acknowledged/respected/ well known in their field of science (external and team). Thought leader and able to talk about field with authority. Expert or at least upcoming expert. Relevant experience as both administrator and life scientist (lab and industry). Track record in academia and/or institutions dedicated to bio-research. Understanding the research field (in depth). As high as possible accomplished in academic domain, ideally PhD but not vital. Well published in reputable journals. Participate in high level forums/ conferences/ congresses. Track record in review of journals. External examiner for higher education. Invited to review panels. International project participation (include hypothesis-driven research).
Stakeholder alignment and support	Ability to collaborate with multiple current and prospective stakeholders/clients. Networked with domain experts/leaders in SA, regional and international. Stakeholder experience and understanding. Be in touch with multiple stakeholders who have sway on the outcomes and direction of the technology. Client, partner and broader stakeholder management. Understand stakeholders and market needs and demand of technology. Aware of own competencies/ relevance to market needs. Able to attract/secure funding from stakeholders to address research challenges within and across fields. Able to find collaborative opportunities/partnerships. Effective resourcing of people/skills and infrastructure. Partnering and collaboration at all levels (local/international science institutions, companies, universities, clients).
Liberate mindsets/ shift paradigms	Open to new inputs. Strategic thinking and foresight for longer-term competitive advantage. Use networks' inputs to guide research. Collaborate where unit lacks skills (local and international). Multi-disciplinary approach. Show interest in areas beyond own expertise area. Able to look beyond own area of expertise for insights to take unit forward. Able to think "outside the box". Knowledge of the science behind the technology. Able to connect science to technology offerings and the market place.
Value creation	Develop new/novel technology (rather than adopting other people's innovations). High-impact output.
Value realisation	Able to map paths for transfer of technology to market via self or associated paths. Able to translate lab-scale work to larger-scale application.
Integrative leadership	Role-model/setting the example in areas, such as dedicated work ethics, innovation thinking/ orientation, lead from front (labs). Clear vision and plan to meet the vision and mission of the CSIR/ goals. Provide strong direction in consultation with the team; leapfrog the team forward. High emotional intelligence. Leadership track record. Integrity that will not be easily influenced by ideas of close colleagues or 'buddies'. Able to make decisions and take accountability for decisions. Can encourage/ motivate/ inspire others via enthusiasm & drive towards common vision/ goals/ relevant outputs. People management skills. Can work with researchers diplomatically. Lead and manage scientists. Grow and support each individual in the team i.t.o. his/her optimal research abilities, outputs and contribution. Able to manage science laboratories and projects, conflict management, convincing speaker/ communicator.
Integrative and business skills	Strong emphasis on multi-disciplinary, multi-organisational and multi-markets/ technology integration through integrative activities and ability to pull different skills together for technology innovation. Ability to develop new business and manage financial and other resources. (More details in Appendix L.)

The researcher did not provide any suggested headings or categories of input upfront, but sorted the inputs into the interim capability clusters discussed in Chapter 3. In a follow-up workshop on 24 November 2015, the same group completed and validated the draft measurement instrument.

5.2.4. Targeted further literature review on innovation process for success

Targeted literature reviews were conducted as envisaged in Chapter 4 to further explore or verify researcher observations related to innovation process assumptions for the identification of technology innovation leader competencies deemed to be required for successful technology innovation. The following observations served as further inputs to enhance the understanding of leader competencies requirements in different research themes. The coding is summarised in Appendix E.

5.2.4.1. Evolving understanding of innovation coincides with increasing complexity

Kotsemir and Meissner (2013:3) believed that an evolving understanding of innovation coincides with evolving innovation models. Increasingly complex innovations and complex surrounding conditions are elements that could be explained by the increasing knowledge sources and applications used in innovation. (Research theme: Technology connectedness)

5.2.4.2. Increasing technology, collaboration and exploitation paths

According to Marinoca and Philimore (cited by Kotsemir & Meissner, 2013:25), technology is playing an ever-increasing role in innovation and linear technology push models have been taken over by innovation collaboration and multiple exploitation paths that will increasingly focus on the individual and framework conditions under which to become innovative (Research themes: Technology connectedness and Stakeholder alignment)

5.2.4.3. Innovation processes take place in an organisational setting

Innovation processes take place in an organisational setting and "...implies more than a structure or process; it is an integrated set of components that work together to create and reinforce the kind of environment which enables innovation to flourish" (Tidd & Bessant, 2013:109). The creation of such an environment should be linked to leader competencies as captured in capability cluster CLMS2 in Appendix D as part of the liberating mindsets research theme for later testing durng the quantitative second research phase.

5.2.4.4. Innovation processes have to keep up with exponential knowledge production

Tidd and Bessant (2013:313) claimed that knowledge production is taking place at an exponential rate, which makes it nearly impossible for firms and their processes to keep up and "...this has been driving traditional R&D practices that occurred within a closed system into obsolescence". Technology connectedness and stakeholder alignment are thus assumed to emerge as alternatives to conventional R&D practice, suggesting that these two interim capability clusters may serve as research themes for the identification of leader competencies.

5.2.4.5. Innovation processes accommodate creative combinations of different disciplines

"Innovation is increasingly about teamwork and the creative combination of different disciplines and perspectives" (Tidd & Bessant, 2013:107), suggesting that the liberating mindsets capability cluster may serve as a research theme for the identification of leader competencies.

5.2.4.6. Innovation processes can improve at the front end

Most innovation process presentations tend to commence with the idea generation stage and conclude with implementation, while some refer to the importance of preparatory steps, yet often without detailed descriptions. This study subscribes to an innovation process which starts with the technology innovation leader understanding the innovation landscape and challenges, as well as opportunities, well enough to influence others to innovate within the areas required. Based on their extensive literature review, Harvey *et al.* (2015:47) concluded that the greatest potential for improving the innovation capability of a firm comes from improving performance at the front end of the innovation and they proposed the concept of "knowing communities" as a key source of creativity that powers innovation.

5.2.4.7. Innovation processes accommodate multiple cumulative progressions

Gopalakrishnan and Damanpour (1997:16) believed that traditional unitary sequence models were used because "... it allows for identification of similar types of innovation processes and facilitates comparisons across innovation situations". They acknowledged another model called the "multiple sequence model" which they described as "complex, with multiple, cumulative and conjunctive progressions of convergent, parallel and divergent activities," but that is where their description ends with no reference to leadership or leader competencies.

5.2.4.8. Innovation processes accommodate T-shaped professionals

Guest (1991:1) proposed and Oskam (2009) expanded the notion of the 'T-shaped professional' or 'hybrid manager' to indicate the need for professionals in different disciplines or functional domains, to acquire sufficient knowledge and understanding beyond their own area of speciality to be able to link with other areas of speciality.

For technology innovation, this implies that the Ts of all involved in the different aspects of the innovation process have to be integrated in pursuit of a seamless integrated series of activities led by the leader and based on the context. (Research theme: Integrative leader)

5.2.4.9. Innovation processes accommodate creative behaviour of people

De Jong and Den Hartog (2007:42) studied the effect of innovation leadership on employees' individual innovative behaviour, and claimed: "Much of the behavioural research on individual innovative behaviour has focused on creativity, for example, on how leaders can stimulate idea generation. However, when and how creative ideas are implemented, a crucial part of the innovation process, is under-researched."

The notion of allocating innovation idea generation to a particular step in the technology innovation process, as implied by most of the innovation process models discussed above, becomes questionable in light of growing evidence from cognitive psychology and neuroscience that there may be several pathways to solving both simple and complex cognitive tasks that lead to creative production (Lubart, 2001). According to Lubart (2001:304), sub-processes involved in creativity recur over and over in complex sequences and a problem definition formulated at the beginning stages of innovation may recur in the middle of the problem-solving when inconsistencies in problem representation prevent further progress. These findings suggest that ideation at one particular stage of the innovation process may thus not be aligned with linear sequential innovation process requirements, which implies that the technology innovation leader may have to be able to solicit creative thinking at any stage of the innovation process.

5.2.4.10. Innovation processes accommodate mobile technologies and new rules

The impact of mobile technologies and the Internet is still not fully appreciated by leaders whose thoughts are based on the "make-and-sell economic model" of the industrial economy, who thinks "...that the core of creating value is to plan and manage a supply chain" (Kilpi, 2015b:1).

> *This is now being supplanted by a different paradigm; a relational, network approach enabled by new coordination technologies. The manufacturer may even be just one of the nodes in the network and the customer is not a passive consumer but an active part of the plan... We are passing through a technological discontinuity of huge proportions. The rules of competition may even be rewritten for the interactive age. The new interactive economy demands new skills: managing the supply-chain is less important than building networks and enabling trust in relations. You could perhaps call the new reversed sequence an on-demand-chain. It is the opposite of the make-and-sell model. It is a chain of relationships and links that starts from interaction with the customer and leads up to the creation of the on-demand offering... A learning relationship potentially makes the whole network smarter with every individual interaction creating network effects. Accordingly, the enterprise increases customer retention by making loyalty more convenient than non-loyalty as a result of learning... The main benefit for the network partners may not be financial. The most valuable thing is to have access to 'community knowledge', a common movement of thought.*

> *It means to be part of a network where learning takes place faster than somewhere else... You and your customer necessarily then become co-operators. You are together trying to solve the customer's problem in a way that both satisfies the customer and ensures a profit for you... The most inspiring and energizing future of work may be in solving problems and spotting opportunities in creative interaction with your customers*. (Kilpi, 2015b:1-3)

Brynjolfsson and Hitt (2000:24) explained that steam technology had fuelled the industrial revolution and that modern-day technology innovation is having similar results, but that more technologies are involved. Today technology innovation can serve a dual role as well. Firstly, technology innovation can enable both productivity enhancements, such as business processes and work practices. Secondly, improved offerings are made possible through reduced costs and improved convenience, time usage, quality and variety. Not only does this take place at a firm level, but also at sectoral and other levels, which exposes the inability of traditional macro-economic measurement approaches to capture these factors in precise numbers because of their multiplying effects. Returns on technology innovation investments are thus likely to be substantially higher than is quantified in traditional frameworks (Brynjolfsson & Hitt, 2000:25) which, for this study, could be interpreted as problematic for the technology innovation leader who has to justify technology innovation investments.

5.2.4.11. Innovation processes accommodate strategic thinking

Another inadequacy in the current technological innovation processes appears to be the near absence of competitive strategy thinking in the visual presentations of the various innovation processes. Porter (1998:176) described a technology strategy as a firm's approach to the development and use of technology. The role of R&D in the firm should be clear considering the pervasive impact of technology on the value chain. Technological change has the power to influence industry structure and competitive advantage, which is why technology strategy has become an essential ingredient in competitive strategy. In technology strategy, a firm must make choices in at least three areas (Porter, 1998:177) that can individually or collectively enhance the firm's sustainable competitive advantage, namely:

- What technologies to develop;
- Whether to seek technological leadership in those technologies; and
- The role of technology licensing.

Scholars in the strategy field have emphasised the significance of social systems theory in strategy formulation. While Porter's view (1998:177) may be interpreted as a rational logic choice between known alternatives, Ungerer, Pretorius and Herholdt (2002:22) referred to quantum mechanics to argue that observers are not neutral and that they cannot distance themselves from their own intentions, wishes, and fears mindsets.

Strategists view things through their own glasses and can never be absolutely objective or claim absolute certainty. The strategic thinking process should be directed towards:

> *...synthesis where the total is always more than the sum of the parts … the emphasis is now on wholes or systems where the relationships between system elements are more important than the elements themselves... it is never only about the key strategic ideas, but more about how these key business ideas relate to each other to form coherent strategic behaviour* (Ungerer *et al.,* 2002:23).

5.2.4.12. Innovation processes should accommodate new thinking and radical theories

Based on a comprehensive literature review on creativity and innovation, Anderson *et al.* (2014:1320) called for new radical theories to be developed based on new insights revealed by scholarly publications. The authors claimed that there has been a notable paucity of research exploring the processes inherent in creativity and innovation compared with the plethora of studies evaluating a multitude of antecedent factors to innovation, to the extent that the field appears to have:

> *...moved away from process research in general, despite earlier publications of valuable process models derived from longitudinal, observational studies in real time with differing organisational settings... Research could also valuably adopt a 'momentum perspective'... for cross-level and multi-level innovation attempts where our understanding of these phenomena could be greatly elucidated by more process research* (Anderson *et al.,* 2014:1320).

Open innovation has been rendering traditional R&D activity or closed innovation obsolete in many firms because of significantly more collaborative innovation with other stakeholders that allow for greater sharing of knowledge and resources, as well as risks associated with technology innovation (Chesbrough, 2011). Technology innovation leaders clearly require competencies to accommodate open innovation as contributor to successful technology innovation by, for example, establishing mutually-beneficial goals, operational protocols and sharing of responsibilities and performance metrics.

An illustrative example comes from the spinal surgery domain where traditional linear sequential processes have been replaced by an iterative design and development cycle as indicated in Figure 5.3 (Bausch *et al.,* 2013:1437).

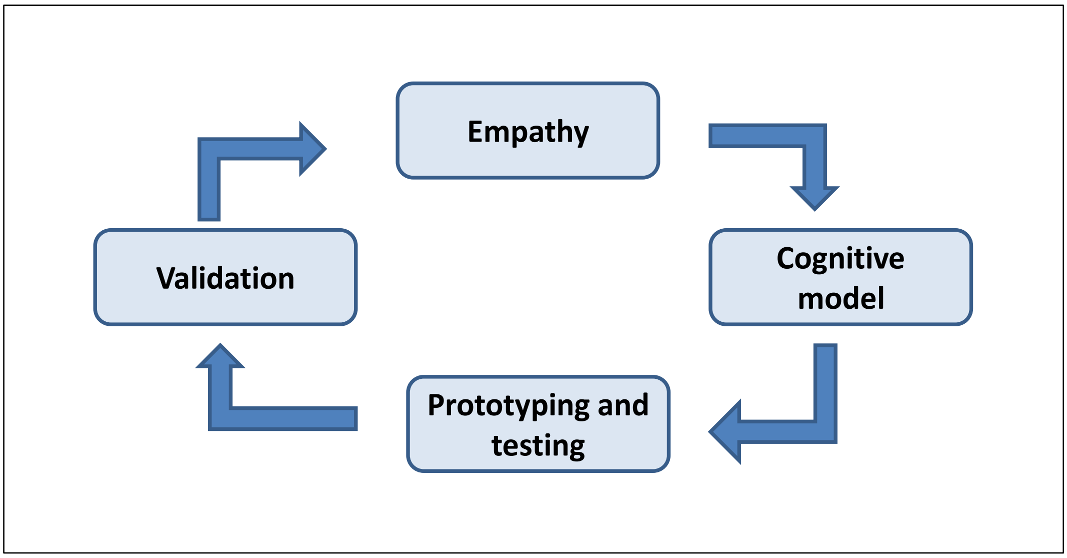


Figure 5.3: Iterative design and development cycle

Source: Adapted from Bausch *et al.*, 2013: 1437.

The iterative design and development cycle of Bausch *et al.* (2013:1437) was derived from a joint initiative by an interdisciplinary team consisting of surgeons, industrial designers, psychologists, educators and engineers. Participants reported two advantages, namely: (i) the opportunity for direct individual contributions by members; and (ii) the opportunity for cross-disciplinary knowledge exchange which created more efficient team innovation.

The iterative design and development cycle illustrated in Figure 5.3 is based on the following four continuously repeating tasks:

- Empathy: This first step familiarises team members with the basic processes and tools to develop a complete understanding of the main problems and their interrelationships.
- Cognitive model: From the observations in the empathy step, explicit knowledge is collected and then complemented by experiential tacit knowledge to give a holistic understanding of the procedural steps and specific challenges.
- Prototyping and testing: This was found to be extremely important in the design and development process because it allows the team to quickly verify the feasibility of an idea, while also providing a powerful communication instrument in interdisciplinary teams to find a common language and discuss further solutions as illustrated in Figure 5.4.
- Validation: The focus is on testing of the newly-created solution with the user under real conditions and verifying the interaction of each component.

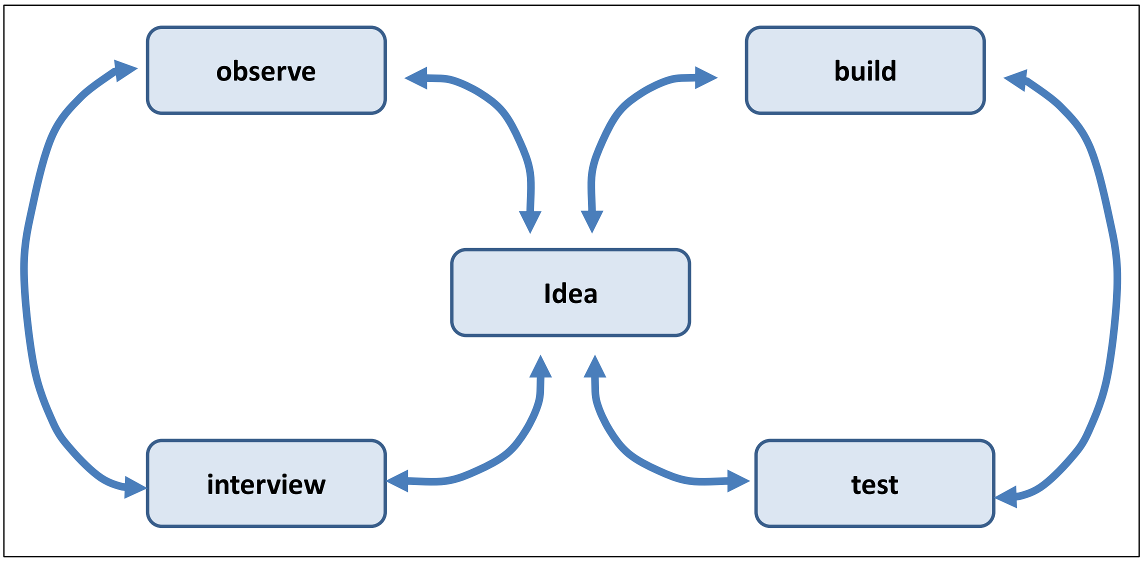


Figure 5.4: Iterative rapid prototyping process

Source: Adapted from Bausch *et al.*, 2013: 1438.

5.2.5. Triangulation of qualitative research data on technology innovation processes

Research data obtained from qualitative research sources was consolidated through collective coding to formulate conceptual constructs as discussed in Chapter 4 and illustrated in Figure 4.10.

5.2.6. Coding of process related qualitative research data for content analysis

Table 5.2 shows process dimensions identified from research data and substantiated in literature together with their codes used for content analysis of the research data obtained by source, as listed and applied in Appendix E. The 37 codes shown in Table 5.2 served as intial coding for the identification of technology innovation leader competencies from innovation process perspectives revealed through the triangulated research data from the different research sources. The same codes were used and adjusted for identification of technology innovation leader competencies as discussed in Section 5.3.

Table 5.2: Competency codes for technology innovation process dimensions

Dimension	Code#	Code	Code origin
Sensing of changing environment	1	Se	Bausch *et al.,* 2013; Kotsemir & Meissner, 2013; Scharmer, 2007; Tidd & Bessant, 2013; Workshop, 2014
Connected to sources of new knowledge	2	TC	Harvey *et al.,*2015; Technovation, 2014; Tidd & Bessant, 2013; Workshop, 2014
Ideation of possibilities from new knowledge	3	Id	Bausch *et al.,* 2013; De Jong and Den Hartog, 2007; Du Preez & Louw, 2008; Lubart, 2001; Swart, 2013; Tidd & Bessant, 2013; Workshop, 2014
Stakeholder inputs are considered	4	SHA	Conway & Steward, 2009; Futurelab, 2014; Lowne, 2007; Muller, 2013; Vlok & Page-Shipp, 2015; Wild, 2015; Workshop, 2014
Paradigm shifts occur in what becomes possible	5	LMS	Elkins & Keller, 2003; Oskam, 2009; Workshop, 2014
External resources may be used	6	Ext	Workshop, 2014
Knowledge from inside and outside is utilised	7	Kn	Smith, 2010; Technovation, 2014; Workshop, 2014
Concept development	8	Con	Smith, 2010
Develop technology	9	Dev	Bausch *et al.,* 2013; Smith, 2010
Design technology	10	Des	Bausch *et al.,* 2013; Smith, 2010
Feasibility both technical and commercial	11	Fe	Smith, 2010; Swart, 2013
Funding for innovation is secured	12	Fu	Brynjolfsson & Hitt, 2000; Workshop, 2014
Portfolio perspectives are considered	13	Por	Du Preez & Louw, 2008
Creating value	14	Cr	Kilpi, 2015b; Workshop, 2014
Creative combinations are tried	15	CC	Conway & Steward, 2009; De Jong and Den Hartog, 2007; Lubart, 2001; Workshop, 2014
Market acceptance is evaluated	16	ME	Smith, 2010; Swart, 2013
Production engineering	17	Eng	Smith, 2010;
Pilot testing	18	Pilot	Bausch *et al.,* 2013; Smith, 2010
Production for delivery	19	Prod	Smith, 2010
Marketing and sales or advocacy activities	20	M&S	Smith, 2010
Suppliers arrangements for production	21	Su	Muller, 2013
Deliver technology	22	Del	Workshop, 2014
Exploit opportunities	23	Expl	Kilpi, 2015b; Workshop, 2014

Table 5.2: Coding of technology innovation process dimensions (continued)

Dimension	Code#	Code	Code origin
Commercialise technology or realise value	24	Com	Smith, 2010; Swart, 2013
Market need serve or create	25	Ne	Kilpi, 2015b; Workshop, 2014
Avoid being locked into process	26	Lo	Brynjolfsson & Hitt, 2000; Gopalakrishnan and Damanpour, 1997; Von Stamm, 2013
Systemic efficiency is pursued across process	27	Effy	Ungerer, Ungerer & Herholdt, 2016
Switching can be done between exploration and exploitation	28	Sw	Bausch *et al.,* 2013; Brynjolfsson & Hitt, 2000; Buijs, 2007; Gopalakrishnan and Damanpour, 1997; Von Stamm, 2013 Elkins & Keller, 2003; Hoque, 2013; Rosing *et al.,* 2011; Tidd & Bessant, 2011; 2013
Compliance may be required	29	Cy	Bausch *et al.,* 2013; Suriyamurthi *et al.,* 2013; Workshop, 2014
Task partitioning varies	30	TP	Tidd & Bessant, 2013; Von Hippel, 1990
Iterative thinking takes place	31	IT	Bausch *et al.,* 2013; Beinecke, 2009; Rosenfeld *et al.,* 2011
Agile, fast, flexible responses to changing landscape	32	AFF	Bausch *et al.,* 2013; Worley *et al.,* 2016
Purpose drives technology innovation	33	Pu	Porter,1998; Ungerer, Pretorius and Herholdt, 2002; Workshop, 2014
Adjust cycle time when environment changes	34	ACT	Bausch *et al.,* 2013; Worley *et al.,* 2016
Simplicity of process for easy understanding and communication	35	Sim	Conway & Steward, 2009
Integration of process elements and activities	36	IL	Baumgartner, 2010; Blanchard, 2010; Conway & Steward, 2009; Elkins and Keller, 2003; Hill *et al.,* 2014; Reisman, 2014; Workshop, 2014
Broad overall plan/framework	37	BOPF	Elkins & Keller, 2003; ExpertJIR, 2014

5.2.7. Suitability of research themes for competencies identification

The preceding disclosures derived from their respective research sources can be interpreted as confirmation of the suitability of research themes for the identification of technology innovation leader competencies deemed to be required for successful technology innovation. The interim set of capabilities in Table 3.14 appeared to be adequately representative of technology innovation processes and was thus applied in the rest of this chapter to identify technology leadership competencies. Table 5.3 provides a summary of research themes together with extended descriptions for greater clarity, as well as corresponding research sources used for their confirmation and use in coding of research data to identify competencies.

Table 5.3: Extended descriptions of research themes from research data

Table 3.14 descriptors	Descriptions of extended research themes	Sources
Technology connectedness	Technology connectedness: Capability to connect with an evolving technology innovation landscape	Baumgartner, 2010; Bausch *et al.,* 2013; Conway & Steward, 2009; De Jong & Den Hartog, 2007; Harvey *et al.,*2015; Hill *et al.,*2014; Kotsemir & Meissner, 2013; Scharmer, 2007; Technovation, 2014; Tidd & Bessant, 2013; Workshop, 2014
Stakeholder alignment	Stakeholder alignment: Capability to align stakeholder support and participation	Conway & Steward, 2009; Futurelab, 2014; Lowne, 2007; Muller, 2013; Vlok & Page-Shipp, 2015; Wild, 2015; Workshop, 2014
Liberating mindsets	Liberating mindsets: Capability to liberate mindsets	Bausch *et al.,* 2013; De Jong and Den Hartog, 2007; Du Preez & Louw, 2008; Kilpi, 2015b; Lubart, 2001; Swart, 2013; Tidd & Bessant, 2013; Workshop, 2014
Value creation	Value creation: Capability to facilitate value creation	Kilpi, 2015b; Ryall, 2013; Smith, 2010
Value realisation	Value realisation: Capability to facilitate value realisation	Chesbrough & Rosenbloom, 2002
Integrative leadership	Integrative leadership: Capability to integrate through leadership	Baumgartner, 2010; Blanchard, 2010; Conway & Steward, 2009; Elkins & Keller, 2003; ExpertJIR, 2014; Hill *et al.,* 2014; Reisman, 2014; Workshop, 2014

The identified innovation process requirements, case materials analyses, practitioners' workshopping and research-theme related literature studies were further used to inform the indentification of competencies related to research themes, from which competencies and behaviours were derived.

5.2.8. Formulation of concepts, constructs and items from content analysis

Research data from the above qualitative research sources and repositories were coded and subjected to content analysis as discussed in Chapter 4 and illustrated in Figure 4.8 to serve as inputs for the identification of leader competencies in the next section.

5.3. LEADER COMPETENCY DATA FROM QUALITATIVE RESEARCH SOURCES

The extended research themes in Table 5.3 served as primary coding frame to identify and populate technology innovation leader competencies deemed to be required for successful technology innovation, as per overall Research Objective 1 in Table 4.2 and Research Objective 4 for the qualitative research phase. Innovation leader competencies have been defined in Chapter 4 as the set of leadership behaviours which are considered instrumental in facilitating and delivering innovation outcomes throughout the various stages in the innovation process. Research themes informed the initial coding frame, which was extended to 37 codes

(Table 5.2) for coding and categorising research data from the research sources observed, and the population of research themes as reported in Section 5.4.

5.3.1. Expert opinions on technology innovation leader competencies

The transcribed personal interview with Dr Bettina von Stamm (2013) also revealed important perspectives on leader competencies that were analysed and integrated with competency perspectives from other experts interviewed. A total number of 281 expert statements were identified from transcribed versions of expert interviews and are listed in Appendix B. These statements were then linked to the literature-derived technology innovation leader behaviours of Appendix C. The descriptions of technology innovation behaviours listed in Appendix B and Appendix C were then combined with Appendix E triangulations to form Appendix D, which reflects the concluding list of technology innovation leader competencies deemed to be required for successful technology innovation that served as content for the draft questionnaire used during the pilot phase of the quantitative component of this study.

5.3.2. Case material on technology innovation leader competencies

Case material was used to verify innovation process assumptions and perspectives in the preceding section. Case material also informed the identification of leader competencies as recorded in Section 5.4. The following cases allowed the researcher to observe the leader behaviours indicated in each case.

The innovation leader identifies the right innovation opportunities and applies design centric innovation. Venture capital firms in Silicon Valley employ their own design partners to lead them through a design-centric process to drive both incremental or breakthrough innovation:

> *Design Thinking is incorporated as an inclusive part of a company's mind and work processes and focuses on framing the right opportunity instead of mere problem solving. They rely on design research to identify design opportunities and drive requirements, which is the core of design centric product development.* (Lie, 2015)

The innovation leader acts as a catalyst and facilitator. Nonaka and Kenney (1991:67) compared the innovation management practices of Canon and Apple and concluded that the leader's role in the innovating firm is that of a catalyst and facilitator, rather than "an all-knowing despot". Futhermore, the importance of innovations is not merely in the product, but also the ripple effect of innovations that can take the organisation into a self-renewal process (Nonaka & Kenney, 1991:67).

The innovation leader uses simplifying frameworks or models to make sense of their complex innovation environments. Tidd and Bessant (2013:340) presented a case study on radical innovation at Philips Lighting to illustrate radical innovation and incremental innovation and how these relate to leader behaviours. They found that people cannot process all the rich and complex information coming at them, so they make use of simplifying frameworks, also known as mental models with which they make sense of the world. The early signals of major change are often not noticed before it is too late to respond, due to the simplified models used, and core competencies become core rigidities. The abilities of leaders to select and reframe these early signals were implied to be of major importance. The interim capability cluster of “liberating mindsets”, as identified in this study, addresses reframing as one of the technology innovation competencies deemed to be required for successful technology innovation. Tidd and Bessant (2013) also reported that when there is a shift to a new mindset, established players may have problems to reorganise their thinking, which requires changing the structure of the frame through which they see and interpret information. The above insights were incorporated in Appendix E.

5.3.3. Practitioners’ inputs on technology innovation leader competencies

A workshop with 34 technology innovation leaders obtained their views on the leader competencies required for success as already reported in Section 5.2.3, Table 5.1. The results of this workshop have been incorporated in Appendix E.

5.3.4. Targeted further iterature review on technology innovation leader competencies

A total of 179 potential technology innovation leader behaviours were identified in literature and have been captured in Appendix C.

5.4. POPULATING RESEARCH THEMES WITH BEHAVIOURS FROM RESEARCH DATA

Each research theme starts with a brief definition derived from content analysis of research data obtained from research sources in this chapter, followed by the identification of leader behaviours or construct items presented as tabular summaries with sources indicated with respect to each research theme, as well as corresponding appendices.

5.4.1. Research theme one: Capability to connect with evolving technological innovation

The technology innovation leader connects with the evolving technology innovation landscape for many reasons that may include gathering of knowledge on new technology alternatives and possibilities to be considered in the envisaged technology innovation, as listed in Table 5.4.

Table 5.4: Capability cluster 1: Being connected with the evolving technology landscape

Behaviour items		Sources
1	The technology innovation leader builds rich and varied ways or **channels** to stay informed of new knowledge and technology innovations to inform unit technology innovation decisions.	Anderson *et al.* (2014), Bracke (2013), Brynjolfsson & Hitt (2000), Dugan & Gabriel (2013), Gliddon (2006), Grayson and Baldwin (2007), Hoque (2013), Smith (2010), Spithoven, Clarysse & Knockaert (2009), Tidd & Bessant (2011, 2013)
2	The technology innovation leader maintains effective networks to **access content sources of expertise** and of the latest science and technology developments that may influence the firm's technology innovation.	Dyer *et al.* (2009), Murray (2002), Osei (2014), Satell (2015), Gliddon (2006), Rosenfeld & Kolstoe (2006), Swart (2013), Porter (1998)
3	The technology innovation leader builds capacity in the unit to **collectively track and process** early signals of emerging technology changes that may influence the operating landscape of the unit.	Criscuolo, Haskel & Slaughter (2005), Elbashir, Collier & Sutton (2011), Osei (2014), Hoque (2013), Scharmer (2007), Spithoven *et al.* (2009), Bausch *et al.* (2013)
4	The technology innovation leader maintains on-going learning (technical and business) to enhance **own credibility** as thought leader.	De la Rey (cited in Wild, 2015), Expert KN (2014), Workshop (2014)
5	The technology innovation leader visualises wider imaginary applications from associating/connecting seemingly unrelated new knowledge and technology beyond current reality in **anticipation of possible future technology innovation.**	Cartwright (2004), Dyer *et al.* (2009), Gliddon (2006), Smith (2010), Prahalad & Krishnan (2008), Jobs (2005), Satell (2015)
6	The technology innovation leader considers future technology **innovation opportunities related to the strategic intent** of the unit.	Elkins & Keller (2003), Muller (2013), Osei (2014), Steyn (2012), Veugelers, Bury & Viane (2010)
7	The technology innovation leader **selects innovation priority areas** with the potential to strengthen the future value of the unit innovation pipeline and/or portfolio.	Osei (2014), Tidd & Bessant (2011), Dugan & Gabriel (2013), Coelux (2015), Veugelers *et al.* (2010)
8	The technology innovation leader detects the **early signals** of emerging opportunities, challenges, problems, players and landscape dynamics as inputs into technology innovation decisions.	CSIR (2010), Hoque (2013), Modesto & Zirger (1984), Osei (2014), Tidd & Bessant (2013)
9	The technology innovation leader continuously **explores** the larger PESTLE (political, economic, social, technological, legal and environmental) environment for technology innovation possibilities.	Bracken (2013), Government of Canada (2007), Porter (1998), Prahalad & Krishnan (2008), Steyn (2012)
10	The technology innovation leader **models** (e.g. business models and technology road maps) alternative futures based on anticipated technology landscape changes.	Bracken (2013), Criscuolo *et al.* (2005), FutureWorld (2014a), Oina and Malecki (2010), Tembinkosi, Lefutso & Nyewe (2014)

5.4.2. Research theme two: Capability to align stakeholder support and participation

Stakeholders are those persons and institutions whose support may influence, in a variety of ways, what would be needed or acceptable in terms of technology innovations. The technology innovation leader seeks alignment between stakeholders' interests and the technology innovation by relating new possibilities to stakeholders' interests in terms of perceived value through behaviours, as listed in Table 5.5.

Table 5.5: Capability cluster 2: Aligning stakeholder support and participation

Behaviour items		Source
1	The technology innovation leader identifies and interacts with stakeholders (opinion shapers and decision-makers), building personal **trust-based relationships** with individuals inside and outside the unit that may influence or contribute to technology innovation of the unit.	Osei (2014), Balmaekers (2014), Bapat *et al.* (2004), Braczak (2015), Gliddon (2006), Prahalad & Krishnan (2008), Rosenfeld & Kolstoe (2006)
2	The technology innovation leader **understands** the needs, political agendas, roles and expectations of stakeholders in relation to anticipated technology innovation.	Dugan & Gabriel (2013), Government of Canada, 2007:2; Schiederig, Tietze & Herstatt (2012), Harvey *et al.* (2015), Jaruzelski & Dehoff, (2010), Rosenfeld & Kolstoe (2006)
3	The technology innovation leader is effective in **obtaining support** for the anticipated technology innovation by making stakeholders understand potential benefits of the new over the current for the respective stakeholders.	Hoque (2015), Moore (2014), Rosenfeld & Kolstoe (2006), Schumpeter (1942), Swart (2013), Tidd & Bessant (2011), Von Stamm (2012)
4	The technology innovation leader **secures resources** that are required for technology innovation, including interaction time of decision-makers.	Bracke (2013). Braczak (2015), Kanter (cited in Katz, 1997), Almonaitiene (2013), Tidd & Bessant (2011), Swart (2013), Von Stamm (2013)
5	The technology innovation leader aligns stakeholder requirements through beneficial or **compelling images** of technology futures that leave stakeholders with a sense of urgency and excitement in anticipation of the envisaged technology innovation.	Gliddon (2006), Government of Canada (2007), Montague (2015), Rosenfeld & Kolstoe (2006), Schiederig *et al.* (2012), Swart (2013)
6	The technology innovation leader **attracts enthusiastic competent innovation talent** to consider as potential team members with complementary profiles and abilities to add value to technology innovation.	Elbashir *et al.* (2011), Rosenfeld & Kolstoe (2006), Swart (2013), Von Stamm (2012)
7	The technology innovation leader avoids, anticipates, detects and **resolves tensions or conflicts** between entities and conflicts of interests pertaining to the technology innovation envisaged.	CSIR (2010); Zenger & Folkman (2014).
8	The technology innovation leader establishes **effective governance and communication mechanisms** through which stakeholders stay informed and influence the development during the envisaged technology innovation.	Conway & Steward (2009), Schmitz & Strambach (2009), Swart (2013), Tidd & Bessant (2011), Von Stamm (2012)
9	The technology innovation leader develops **innovation design parameters** based on requirements and **motive**s of decision-makers and opinion leaders. (Positive value experiences)	Tidd & Bessant (2011), Von Stamm (2012)

5.4.3. Research theme three: Capability to liberate mindsets

The technology innovation leader builds one or more teams of people to participate in the envisaged innovation through a variety of ways that are initiated and accommodated by the leader. Members' backgrounds may inspire them to default in their thinking to what they know and what they are comfortable with and thus prevent them from possibility thinking. The technology innovation leader creates an environment where paradigms are shifted and mindsets are liberated, as listed in Table 5.6.

To further enhance understanding of this leader capability, some additional explanatory perspectives are offered, starting with two citations:

> *"To raise new questions, new possibilities, and to regard old problems from a new angle, requires creative imagination and marks real advance in science*" — Albert Einstein (Mayer & Holms, 1996).

> *To harness technology for business transformation in the digital age, several barriers have to be addressed, such as "...functional silos, rigid ideas about roles and responsibilities, calcified processes, outdated compensation structures and technology infrastructures that were not designed to support the kinds of open and agile customer-engaging systems required today"* (Whitehurst, 2014:3).

These citations reflect that deliberate leader stimulation of thinking is required for successful technology innovation which goes beyond idea generation practices to include the technology innovation leader's critical ability to bring about new paradigms of technology innovation possibilities by linking new science and technology breakthroughs with stakeholders' interest in creative new combinations (Rosenfeld & Kolstoe, 2008; Von Stamm, 2012).

Technology innovation leaders create an environment in which new thinking flourishes and diversity stimulates creative interactions (Rosenfeld & Kolstoe, 2006; Andersen *et al.,* 2014). New ideas are captured and processed through creative energies to determine feasible alternatives towards the innovation vision (Tidd & Bessant, 2011; Rosenfeld & Kolstoe, 2006; Von Stamm, 2012). According to experts interviewed, the technology innovation leader encourages on-going identification of possible technology improvement areas for integrated technology solutions by using framing and reframing of challenges or opportunities so that innovation team members can see their contribution in the way forward.

The research data suggested that the successful technology innovation leader does more than generate ideas, and would rather aim for new paradigm possibilities becoming conveivable as a result of combining new things in new ways. If diversity is to serve as a source for technology innovation, people and organisations may have to adjust their practices, including their thinking practices. Andersen (2014) proposed meta-cognition, or thinking about thinking, suggesting that it will become increasingly difficult to compete by using processes that everyone else uses.

Prof Rosabeth Moss Kanter (2002) referred to kaleidoscope thinking as a vital skill for the future because one's own view of things may no longer be adequate. McKeown spoke about tapping into a bigger brain to benefit from multiple perspectives. Rosenfeld and Kolstoe (2006) insisted that managers often suffer from their own blind spots and ego needs. They proposed a Mosaic programme that makes invisible people-related aspects visible and helps others to discover the power of diversity.

Table 5.6: Capability cluster 3: Liberating mindsets

Behaviour element		Source
1	The technology innovation leader ensures **innovation team diversity** by appointing open-minded members with diverse experiences, backgrounds, disciplines and competencies and personal attributes needed to realise the technology innovation vision.	Balmaekers (2014), Dyer *et al.* (2009), Gliddon (2006), Harvey *et al.* (2015), Hill (2016), Rosenfeld & Kolstoe (2006), Rosenfeld *et al.* (2011), Swart (2013), Tidd & Bessant (2011), Zhang, Song, Hackett and Bycio (2006)
2	The technology innovation leader creates an **innovation-conducive environment** for team interactions that optimise member contributions through exchange and discussion of ideas and sensitive information without having to fear victimisation.	Anderson *et al.* (2014), Elkins & Keller (2003), Hammett (2007), Hill (2016), Kline (2008), Rosenfeld & Kolstoe (2006), Swart (2013), Tidd & Bessant (2011), Ungerer (2009), Von Stamm (2012), Rosing *et al.* (2011)
3	The technology innovation leader stimulates and **provokes unfamiliar or unconventional ideas and thinking** as building blocks towards the achievement of the technology innovation vision.	Amabile (1998), Adair (2009), Balmaekers (2014), De Bono (2000), Gliddon (2006), Hill (2016), Kanter (1999), Nolan & Robinson (2000), Osei (2014), Rosenfeld & Kolstoe (2006), Skarzynski & Gibson, 2008), Swart (2013), Tidd & Bessant (2011), Vincent (2015), Von Stamm (2012),
4	The technology innovation leader uses effective creative thinking practices and discovery skills to **overcome entrenched beliefs or establish new paradigms from which new thinking is possible.**	Dyer *et al.* (2009), Dyer, Gregersen & Christensen (2011), Horth (2004), Hill (2016), Osei (2014), Rosenfeld & Kolstoe (2006), Skarzynski & Gibson, 2008). Swart (2013), Von Stamm (2012)
5	The technology innovation leader uses effective mechanisms allowing people to **capture** and submit their innovation ideas for consideration.	Prekel (2010), Swart (2013)
6	The technology innovation leader facilitates **integrative technology solutions thinking** in support of the technology innovation vision.	Tidd & Bessant (2011), Von Stamm (2012)
7	The technology innovation leader fosters constructive positive team dynamics and resolves people tensions without delay so that the team can **channel their creative energies** towards the innovation vision.	Coelux, (2015), Gliddon (2006), Kanter (1999), Skarzynski & Gibson (2008), Swart (2013), Tidd & Bessant (2011)
8	The technology innovation leader establishes routines and capabilities in the team to **spot possible technology improvement areas and determine the feasibility** of new ideas.	Dyer *et al.* (2011), Hauser, Meinecke & Schroeter (2008), Lewis *et al.* (2002), Oina & Malecki (2010), Swart (2013), Tidd & Bessant (2011), Von Stamm (2012)
9	The technology innovation leader aims to ideate **technology innovation-based value improvement for a stakeholder** rather than adhering to highly-detailed work plans and tight control during ideation, as it will inhibit creativity efforts of team members.	Baumgartner (2010), Mashelkar (2010), Oina & Malecki (2010)
10	The technology innovation leader ensures that technology innovation **design parameters are contextualised** by framing problems, challenges, opportunities and requirements to solicit original thinking.	Swart (2013), Hill (2016), Von Stamm (2012)

5.4.4. Research theme four: Capability to facilitate value creation

Value creation implies the conversion of newly-generated ideas or conceptual possibilities into experimental designs, prototypes or technology demonstrators that can be assessed by stakeholders in terms of the monetary, strategic or other forms of value associated with the invention through behaviours listed in Table 5.7.

Table 5.7: Capability cluster 4: Facilitation of value creation

Behaviour item		Source
1	The technology innovation leader establishes effective practices for converting promising but still vague concepts into **concrete tangible value manifestations** such as prototypes, technology demonstrators, and experimental designs that illustrate what the technology can do.	Dyer *et al.* (2009), Jaruzelski & Dehoff (2010), Sloane (2009b), Tidd & Bessant (2011), Von Stamm (2012), Wilson (cited in McKinsey Insights, 2014a)
2	The technology innovation leader re-constitutes the technology innovation team if needed to ensure that required capabilities (like skills, equipment and infrastructure) are available for testing and refining and producing **technology innovations perceived to be valuable** by stakeholders.	Bausch *et al.* (2013), Hauser *et al.* (2008), Rosenfeld & Kolstoe (2006), Swart (2013), Von Stamm (2012)
3	The technology innovation leader establishes effective individual and collective team capabilities to solicit and process **stakeholder feedback** that may be used to enhance future demand for the invention/ improve value of the technology innovation (revenue potential)	Braczak (2015), Bry (2015), Gliddon (2006), Heyns (2014), Jaruzelski & Dehoff (2010), Stone & Clark (2016:1), Von Stamm (2012)
4	The technology innovation leader **acknowledges the potential disruption** that may come with new technology innovation to avoid unintended negative consequences.	Bracken (2013), Colins (2005), Prekel (2010), Rosenfeld & Kolstoe (2006), Vermeulen (2011)
5	The technology innovation leader facilitates **simulation and exploration** of technology parts and configurations to consider customisation for different applications and stakeholder segments.	Oina & Malecki (2010), Scharmer (2007), Von Stamm (2012)
6	The technology innovation leader facilitates effective decision-making by all involved to reach informed **stop-or-go decision**s based on agreed and shared criteria that combine disparate or even opposing ideas.	Borjesson *et al.* (2014), Kelley (2010), Oina & Malecki (2010), Riedl, Blohm, Leimeister & Krcmar (2010), Swart (2013), Tidd & Bessant (2011)
7	The technology innovation leader establishes effective mechanisms to identify and protect new **intellectual property** flowing from team deliberations.	Lichtenhaler, Lichtenhaler & Frishammar (2009)
8	The technology innovation leader conducts rapid experimentation, value modelling and progress assessments to **enhance technology readiness and adoption readiness levels** of the new technology for introduction to and adoption by targeted individuals and groups.	Bausch *et al.* (2013), Bronet, Eglash, Gabriele, Hess & Kagan (2003), Hauser *et al.* (2008), Oina & Malecki (2010)

Table 5.7: Capability cluster 4: Facilitation of value creation (continued)

Behaviour item		Source
9	The technology innovation leader networks effectively with members from other departments and business units to create cross-functional **collaborative commercialisation teams** to ensure adoption of the new technology (alone or as products, services or processes).	Chesbrough (2011), Swart (2013), Von Stamm (2012)
10	The technology innovation leader establishes **effective collaborative innovation** through effective negotiation with collaborators and partners to commercialise products, services and/or processes successfully into the market or value chain.	Carayannis & Chanaron (2007), Prahalad & Krishnan (2008), Swart (2013), Tidd & Bessant (2011), Von Stamm (2012)

The experts interviewed claimed that creative thinking needs to be converted into technology demonstrators, prototypes or experimental designs that illustrate what the new technology can do, so that people can associate technology innovation with anticipated benefits.

5.4.5. Research theme five: Capability to facilitate value realisation

Value realisation means the scaling and deployment activities associated with the adoption and implementation of technology innovations to achieve market saturation through behaviours listed in Table 5.8.

Table 5.8: Capability cluster 5: Facilitation of value realisation

Behaviour items		Source
1	The technology innovation leader facilitates the development of a **market entry model and strategy** (e.g. third-party licensing, sale or own commercialisation start-up) in which critical success factors for market entry are identified and accommodated.	Grulke & Silber (2001), Oina & Malecki (2010), Petersen (2015), Teece (2010), Swart (2013), Tidd & Bessant (2011)
2	The technology innovation leader facilitates **co-creation of integrated solutions with stakeholders** to ease adoption during technology introduction and diffusion.	Berthon, Hulbert & Pitt (1999), Hauser *et al.* (2008), Perez (2009:4), Stefanovich (2011), Tidd & Bessant (2011), Von Stamm (2012)
3	The technology innovation leader uses networks, client demands, regulatory forces and success stories to **establish market support** for the new technology to become the standard for specifiers and regulators of technology solutions.	Perez (2009:4), Rosenfeld & Kolstoe (2006), Schaffers, Komninos, Trousse, Nilsson & Oliveira (2011), Smith (2010), Swart (2013)
4	The technology innovation leader provides **educational support on new technologies** for smooth implementation and adoption of technology innovations.	Sernack (2014), Stanford Graduate School of Business (2013), Von Stamm (2012)

Table 5.8: Capability cluster 5: Facilitation of value realisation (continued)

Behaviour items		Source
5	The technology innovation leader maintains **agile responsive capacity** in the innovation team to monitor and respond to anticipated and un-anticipated implementation challenges (technology and market).	Love, Irani & Edwards (2004), Petersen (2015), Von Stamm (2012)
6	The technology innovation leader establishes an **innovation eco-system** that keeps the innovation members and stakeholders networked for on-going learning and refinement of technology innovation practices.	Aspen Institute (2015), Hoque (2015), Rosenfeld & Kolstoe (2006), Le Storti, (2003), Sernack (2014), Swart (2013), Tidd & Bessant (2011), Von Stamm (2012)
7	The technology innovation leader facilitates **effective transfer of the new technology** in line with the selected commercialisation business model.	Rosenfeld & Kolstoe (2006), Swart (2013)
8	The technology innovation leader monitors and manages technology **deployment** levels in line with demand levels and production capabilities.	Lee, Park, Yoon & Park (2010), Petersen (2015), Swart (2013)
9	The technology innovation leader explores technology **platform expansion/ scaling opportunities** for greater investment returns through collaborative relationships with others in supply chain delivery.	Gawer & Cusumano, (2002), McKinsey Insights, (2014b), Reisman (2014), Swart (2013), Tidd & Bessant (2011), Von Stamm (2012)
10	The technology innovation leader engages **on-going technology innovation support** to broaden understanding of potential future technology innovation opportunities, such as R&D and innovation communities.	Beinecke (2009), Rosing *et al.* (2011), House (1996), Swart (2013), Von Stamm (2012)

5.4.6. Research theme six: Capability to integrate through leadership

Integrative leadership means the ability of the technology innovation leader to integrate work across capability clusters throughout the technology innovation process to bring about successful technology innovation by setting the example, getting people to work together, and resolving apparent contradictions or situations of paradox, as the technology innovation evolves. The associated behaviours are listed in Table 5.9. The potentially profound significance of this leader capability warrants an additional discussion to contextualise the need for the leader to be competent in bringing together technology, business and people elements.

While proponents of ideation may favour an unstructured entry into the technology innovation journey, others favour disciplined regimes, according to experts interviewed. The integrative leader behaviours of the technology innovation leader are often the most important contributions to successful technology innovation, according to experts interviewed. These behaviours deal with human factors that have been found to be critical for success of technology innovation leaders (Rosenfeld & Kolstoe, 2006) including being a role-model for others and leading through inspirational and an intellectually-challenging innovation vision, according to experts interviewed.

The experts interviewed also believed that the technology innovation leader engages and empowers other people involved in the technology innovation and supports and motivates them through what they value and related recognition and reward. Constructive, timely feedback is provided by the technology innovation leader to ensure learning contributes to innovation energy (Tidd & Bessant, 2011). The integration of all elements of technology innovation determines the success rate of the technology innovation leader, according to experts interviewed. Successful technology innovation leaders provide a broad overarching framework or plan to direct the innovation focus, while creating team awareness and sense of belonging for team members to come up with solutions for innovation challenges and exploit innovation opportunities, according to experts interviewed.

Chemers (2014:1) supported the integrative competencies of innovation leaders and added that innovation is "...a process of social influence in which one person is able to enlist the aid and support of others in accomplishing a common task". Cohen (2014) suggested that the roles of management and leadership have much to do with integration of people into an organisation. The integrator incorporates people as equals into the organisation to maximise their contributions for the good of the organisation, and its overall purpose. Through their disparate views, people contribute to the production of products, development and delivery of service offering, or the organisation's business model, in value-adding, meaningful and sustainable ways.

Table 5.9: Capability cluster 6: Integration through leadership

Behaviour items		**Source**
1	The technology innovation leader leads by example as **role-model** in original thinking, exploring opportunities, generating ideas, learning from experience and determining the feasibility of ideas for value creation and value realisation with strong emphasis throughout on the interrelatedness of all innovation activities.	Beinecke (2009), De Jong & Den Hartog (2007), Hill (2016), Kouzes & Posner (1995), Von Stamm (2012)
2	The technology innovation leader develops and communicates an **inspirational and intellectually-challenging innovation vision** and strategic purpose to scope the preferred types of innovation and direction for the innovation team. This may include problems, challenges or opportunities.	Blake (2003), Börjesson *et al.* (2014), De Jong & Den Hartog (2007), Elkins & Keller (2003), Gill (2011), Gliddon (2006), Gryskiewicz & Taylor (2003), Rosenfeld & Kolstoe (2006), Van der Laan (2016), Von Stamm (2012), Zenger & Folkman (2014)
3	The technology innovation leader **engages people before initiating changes** that may affect them, incorporating their ideas in the technology innovation processes.	De Jong & Den Hartog (2007), Kouzes & Posner (1995), Von Stamm (2012)
4	The technology innovation leader **empowers** members by establishing shared ownership and allowing members sufficient freedom and autonomy to determine by themselves or with others how to meet their innovation objectives. This includes being allowed to make mistakes and learn from them.	Bandura (1977), Coelux (2015), Conger & Kanungo (1988), De Jong & Den Hartog (2007), FutureWorld (2014b), Gemmill & Wilemon (Katz, 1997), Krause (2004), Stefanovich (2011), Von Stamm (2012)

Table 5.9: Capability cluster 6: Integration through leadership (continued)

Behaviour items		Source
5	The technology innovation leader **supports and motivates** members by giving them space to do what they value, both in times of passion and pain. This includes acting friendly, showing respect, being patient and helpful, listening, and looking out for someone's interests if problems arise.	De Jong & Den Hartog (2007), Hill (2016), Rosenfeld *et al.* (2011), Von Stamm (2012)
6	The technology innovation leader uses **recognition and reward mechanisms to show appreciation** for innovative performances of those involved to acknowledge innovation contributions of team members.	De Jong & Den Hartog (2007), Experts interviewed
7	The technology innovation leader oversees on-going innovation progress and **provides constructive, timely feedback** to team members during innovation, to learn from success and failures during innovation.	De Jong & Den Hartog (2007), Hill (2016), Stefanovich (2011)
8	The technology innovation leader radiates **positive innovation energy** rooted in positive attitude, group dynamics and organisational support for vision-aligned technology innovation.	Tidd & Bessant (2011), Von Stamm (2012)
9	The technology innovation leader **facilitates systemic integration** of technology innovation through alignment of all elements (technical, human, business).	Beinecke (2009), Buijs (2007), Chemers (2014), Enninga & Van der Lugt (2016), Henderson (1994), Hill (2016), Kelley (2010), Krippendorff (2013), Pampallis (2016), Quast & Vaaler (2013), Stefanovich (2011)
10	The technology innovation leader facilitates an overarching broadly-defined **innovation architecture, logical framework and/or plan** for the envisaged innovation.	Bracken (2013), Rosing *et al.,* (2011), Tidd & Bessant (2011), Vermeulen (2011),
11	The technology innovation leader solicits intense **near-obsession-like levels of ownership** for generating solutions to innovation challenges, opportunities or problems.	Brands (2014), Crosby (2008), Shamir *et al.* (1993), Von Stamm (2012)

5.5. EMERGING ELEMENTS OF A TECHNOLOGY INNOVATION LEADERSHIP THEORY

5.5.1. Overview

Section 5.4 identified the potential technology innovation leader behaviours that make up the technology innovation leader competencies deemed to be required for successful technology innovation. Research themes were used to process qualitative research data in order to identify specific leader behaviours from the data obtained from research sources.

A coherent, integrative view of the research themes is presented as potential elements of an emerging theory, based on the research data obtained from the qualitative research sources and further substantiated by supplementary scholarly perspectives.

While systemic interrelationships between leader competencies have been suggested as important in Section 1.2 and Section 3.9.1, research data from the qualitative research phase appear to support this notion. Technology innovation can indeed be described as complex and multi-faceted, where each step taken by the technology innovation leader can have "...consequences both upstream and downstream" (Buijs, 2007:206).

For Anderson *et al.* (2014:1299), the innovation process "...as it unfolds over time is messy, iterative, and often involves two steps forward and one step backwards, plus several sidesteps". Anderson *et al.* (2014:1318) called for the integration of idea generation and idea implementation subfields within the body of knowledge and concluded: "Akin to two siblings who fell out at a family gathering in the distant past, the subfields of idea generation and idea implementation remain doggedly disconnect from one another". Anderson *et al.* (2014:1299) emphasised that:

> *[despite the growing body of knowledge] ...there remains a lack of general agreement between researchers over what constitutes precisely either creativity or innovation, with different studies using rather different operationalisations of each concept ... some scholars have advocated a stronger conceptual differentiation between creativity and innovation ... other authors have argued that creativity occurs not only in the early stages of innovation processes but, rather, they suggest a cyclical, recursive process of idea generation and implementation.*

While Buijs (2007) emphasised the integration of technology innovation processes (2007) Anderson *et al.* (2014), emphasised that technology innovation processes should be accessible to engage the imaginative capacities of all those involved. For Anderson *et al.* (2014) the precondition is imagination; and imagination requires creativity related to an understanding of where innovation comes from, including finding customers with unmet needs, developing a value proposition to serve those needs and finding a way to make it happen.

Anderson *et al.* (2014) claimed that most people approach problem-solving in a linear way, whereas creativity starts with thinking in a non-linear way. Creativity involves seeing what others see, but seeing something new and this requires thinking beyond what most working professionals were trained to do (Anderson *et al.,* 2014).

Anderson (2014) introduced meta-cognition as the ability of some people to think about the way they are thinking, or active thinking which he linked to the requirements relating to problem sensibility, liquidity or different ways of thinking as multiple perspectives, flexibility to alternate between different perspectives, elaboration (which is thinking outside the boundaries), and originality or not copying what exists. Anderson (2014) claimed that different professions would deal differently with the same problem, which necessitates the adoption of innovation processes that raise different perspectives from which solutions emerge.

The fear of looking bad is regarded as the major reason why people resist letting go of their assumptions and not taking part in innovation (Anderson, 2014; Hogan & Coote, 2014). An environment that does not protect people from negative consequences of creative behaviour will inhibit them. Such an environment could exist because of the hierarchy, culture, leadership style, questioning approach, and in particular questioning learning, experience, culture and values (Anderson, 2014).

Hunter and Cushenbery (2011) proposed a model for innovation leadership based on direct and indirect leadership influences across the innovation process, which they represented as a generation phase, evaluation phase and implementation phase. Individuals generate ideas and "propose them to their team who takes the idea, makes alterations and fine-tunes it to the point of making prototypes, formalised sketches, or simulations" (Hunter & Cushenbery, 2011:250). These phases are not independent of one another and should not be viewed in a "lock-step fashion," meaning that there are both backward and forward influences and activities affecting each of the three stages (Hunter & Cushenbery, 2011:251). Lubart (2001:304) gave a similar perspective by suggesting that several authors have proposed a recursive application of idea generation and idea evaluation in cyclic, dynamic cycles.

Adner and Levinthal (2001) discussed two approaches to technology innovation. One approach suggests that innovation is driven by external requirements of the market and the other is that the activities and internal capabilities of firms are the primary drivers of technology innovation. Taken in isolation, each approach has merit, but the greatest insight flows from their joint consideration, according to Adner and Levinthal (2001:611). They called for a balance between these two approaches and observed that by far the larger portion of technological advancement is currently concentrated on the supply-side dynamics, which underplays the significance of innovation that is influenced or even led by customer involvement, because opportunities are interpreted within the firm's current set of capabilities.

The various perspectives discussed confirm the inadequacies associated with some established innovation processes and strengthen the case for considering a more dynamic and integrative technology innovation process. This is an approach that would manifest in the technology innovation leader not being tied to any particular technology innovation process, as discussed in Chapters 3 and 5. It is therefore argued that a more contextually-driven choice of the sequence in which a technology innovation process unfolds would be better served by the existence of different sets of capabilities that the technology innovation leader would be able to tap into to achieve technology innovation success. The technology innovation leader should be able to establish and maintain technology intelligence sources to make sense of changes and trends in the technological innovation environment to inform decisions on their own technological innovation. The technology innovation leader should be able to solicit knowledge, resources and support from the various stakeholders and endorsement of the technological innovation direction.

The technology innovation leader must be able to liberate the mindsets of the people involved to pave the way for the creative contributions to be made beyond existing paradigms and what is known and already in place. New imaginary possibilities from liberated mindsets need to be concretised as demonstrable prototypes or technology demonstrators that are perceived to be of value.

The personal integrative capabilities of technology innovation leaders and the capabilities in the innovation team are critical to integrate all identified variables in terms of capabilities, technologies, people, priorities and resources in the technology innovation process.

Figure 5.5 shows the research themes thus far included in the provisional conceptual model in Figure 1.6 as leader capabilities representing leader behavioural items that may interconnect to shape technology innovation, from detecting the first opportunity signals to the point of realising value from deployed technology. These may represent the elements of an emerging integrative technology innovation leadership model or theory and are aligned with the conceptual model of this study presented in Chapter 1. ‘Model’ refers to a framework, pattern or blueprint, while ‘theory’ refers to “an idea or system of ideas intended to explain something” or “a set of principles on which an activity is based” (Oxford Dictionary, 2009).

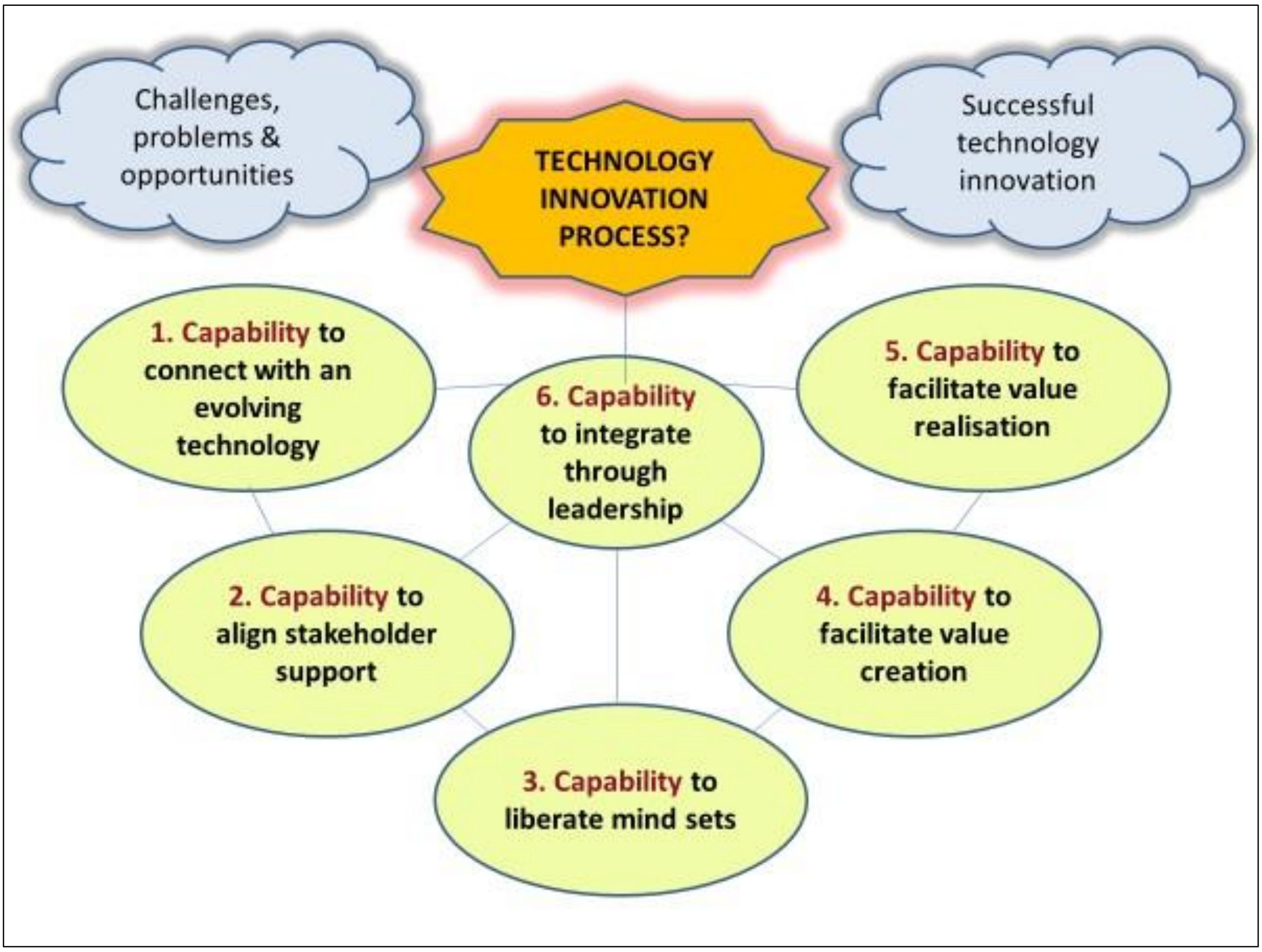


Figure 5.5: Research themes as leader capabilities

5.5.2. Formulation of concepts, constructs and items from content analysis

Research data from qualitative research sources were used for both the validation of technology innovation process assumptions and identification of technology innovation leader competencies deemed to be required for successful technology innovation, as discussed in Chapter 4, outlined in Figure 4.10 and presented in the preceding sections of this chapter.

While the details of each capability cluster or construct and corresponding behaviours presented are self-explanatory, the following insights emerged from the analysis.

Capability cluster 1 revealed that the technology innovation leader takes personal responsibility for staying connected to the technology landscape and stakeholders, rather than relying on other structures to obtain and interpret such information on their behalf. These leaders also model different possibilities for their potential relevance to the strategic intent of their organisations.

Capability cluster 2 revealed that trust-based relationships with stakeholders are important for discussing confidential or sensitive matters, such as their views about technology innovation. Only when technology innovation leaders can relate to these stakeholders' interests, are they capable of securing resources, including the time and support of stakeholders.

Capability cluster 3 revealed that technology innovation leaders go beyond the use of creativity techniques and ideation methods. They raise the paradigm in teams to allow the members to sense new possibilities that relate to paradigm shifts.

Capability cluster 4 revealed that the prototyping or experimental design activities that often follow idea-generation activities, may be incorporated in an interactive idea generation activities combined with rapid prototyping through which the technology innovation leader allows for members to remain focussed on value creation.

Capability cluster 5 revealed that technology innovation leaders do not leave the commercialisation aspects of innovation for the end of the innovation process. They consider value capturing possibilities the first conceptualisations of possible new technology innovations, and use innovation eco-systems to refine their assumptions.

Capability cluster 6 revealed that most of the technology innovation leader behaviours identified endorse leader behaviours identified before by others. What is different, however, is the inclusion of positive innovation energy which has not been observed by other studies. The technology innovation leader's competency to bring about intense levels of individual and collective ownership in their team for generating solutions to innovation challenges, is also different.

The capability clusters identified, thus appear to be representative of the technology innovation leader competencies deemed to be required for successful technology innovation, and may be used to further refine and test these as new insights emerge.

5.6. PRE-QUANTITATIVE PHASE REFLECTIONS

The great innovator, Leonardo da Vinci, was driven by curiosity (Gelb, 2004) and so was the great technology innovation leader, Steve Jobs (Isaacson, 2011). The researcher was curious to find a link between the constructs identified as per Research Objective 1 in Table 4.2 and innovation lessons ascribed to the late Steve Jobs, as recorded by Isaacson (2011). Table 5:10 shows the researcher's interpretation of Isaacson's (2011) descriptions of leader behaviours and in which construct areas of this study similar leader behaviours had been captured.

Table 5.10: Constructs matched with lessons learned

Lessons and quotations by Steve Jobs	TC	SHA	LMS	VC	VR	IL
The most enduring innovations marry art and science. (iPad look and feel)	x		x	x		x
To create the future, you can't do it through focus groups.		x	x	x		x
Never fear failure (being fired by the successor he had selected).			x			x
You can't connect the dots forward – only backward. So, you have to trust that the dots will somehow connect in your future.	x		x		x	x
Listen to that voice in the back of your head that tells you if you're on the right track or not.			x			x
Expect a lot from yourself and others.		x				x
Don't care about being right. Care about succeeding.			x	x	x	x
Find the most talented people to surround yourself with.	x		x	x		x
Stay hungry, stay foolish.			x			x
Anything is possible through hard work, determination, and a sense of vision.			x			x
Technology is nothing. What's important is that you have a faith in people, that they're basically good and smart, and if you give them tools, they'll do wonderful things with them.			x		x	x

Legend: TC: technology connectedness, SHA: stakeholder alignment, LMS: liberating mindsets, VC: value creation, VR: value realisation, IL: integrative leadership

Source: Compiled by researcher from Isaacson, 2011.

The mapping of the constructs derived from this study against a published list of the late Steve Job's insights or technology innovation leader lessons learned in Table 5.10 concludes the qualitative research phase. The qualitative research objectives in Table 4.6 and Research Objective 1 in Table 4.2 have been achieved and thus provide inputs for the development of a measurement instrument for Research Objectives 2, 3 and 4 in the remaining chapters.

5.7. CHAPTER CONCLUSION AND SYNTHESIS

This study aims to identify technology innovation leader competencies deemed to be required for successful technology innovation. This chapter addressed the qualitative first phase of this sequential exploratory design study, where content analysis was used to analyse research data obtained from expert interviews, case material, workshop inputs and literature. The result is a set of interim capability clusters that were populated with supporting leader behaviours for inclusion in the measurement instrument developed for data gathering during the second qualitative research phase.

The provisional conceptual model presented in Figure 1.6 was sufficiently supported by qualitative research data to retain the interim capability clusters and populate these with technology innovation leader competencies derived from content analysis and triangulation.

The findings corresponded with insights gained during the literature review, with particular reference to a move away from predetermined fixed technology innovation processes towards more flexible and context-specific process flows. While the literature provided perspective on these shifts, the research sources used in the qualitative research provided specific technology innovation information on the processes and leader competencies that successful technology innovation leaders applied to accomplish successful technology innovation.

The purpose of a results chapter is to report and discuss findings and reflect on their implications, which is what was done in this chapter. Research findings need to be subjected to quantitative approval or rejection of interim propositions, which become hypotheses after the planned pilot study and are subjected to statistical verification of relationships in the next chapter (Bryman & Bell, 2011:681)

CHAPTER 6

QUANTITATIVE RESEARCH PHASE RESULTS

6.1. CHAPTER INTRODUCTION

Chapter 4 revealed the research design and methodology. The research paradigm, scope and sources were discussed as well as the development and validation of the measurement instrument used for the main survey. This chapter describes the findings of the data collection and analysis as part of the process to identify technology innovation leader competencies deemed to be required for successful technology innovation, as outlined in Chapter 4. Figure 6.1 indicates the key elements and messages addressed in this chapter.

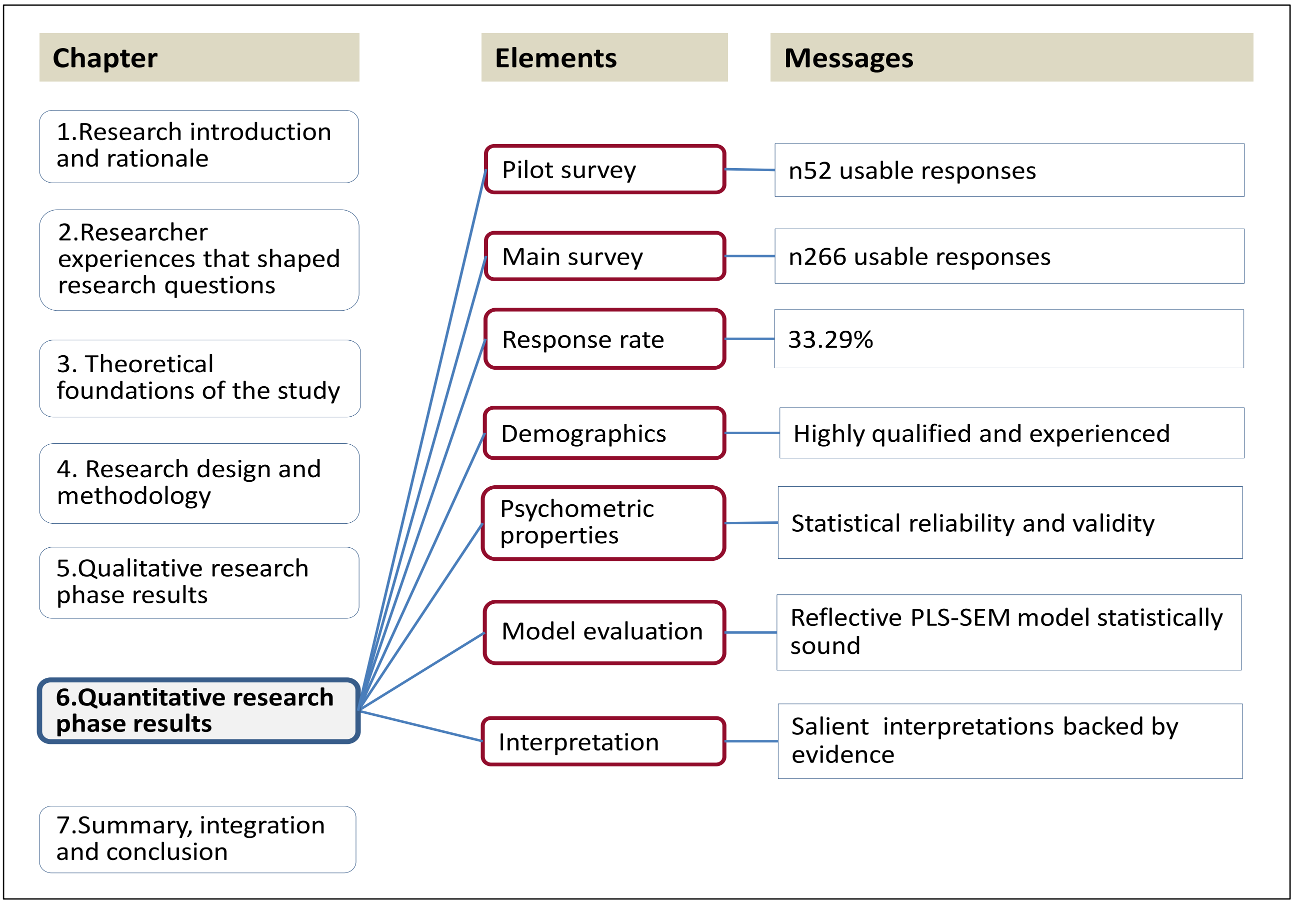


Figure 6.1: Thesis map of Chapter 6

6.2. PILOT SURVEY RESULTS

As discussed in Chapter 4, statistical analysis of research data from 52 completed pilot survey responses were conducted and yielded the following results.

6.2.1. Pilot survey results on innovation beliefs

Innovation beliefs of respondents were captured through the online questionnaire, by asking them to what extent they agreed or disagreed: (i) that technology innovation is achieved when value is derived from its adoption or deployment; (ii) that technology innovation processes may not take place in a linear sequential manner; and (iii) that identified capability clusters would feature in their technology innovation processes. The findings are summarised below:

- 79 percent agreed (50% strongly agree plus 29% agree) that technology innovation is only achieved when value is derived.
- 90 percent agreed (54% strongly agree plus 36% agree) that technology innovation may not follow a linear sequential process.
- 89 percent agreed (43% strongly agree plus 46% agree) that technology connectedness is one of the capability clusters that are deemed to be required for successful technology innovation.
- 89 percent agreed (50% strongly agree plus 39% agree) that achieving stakeholder alignment is one of the capability clusters that are deemed to be required for successful technology innovation.
- 82 percent agreed (50% strongly agree plus 32% agree) that liberating mindsets is one of the capability clusters that are deemed to be required for successful technology innovation.
- 89 percent agreed (43% strongly agree plus 46% agree) that value creation is one of the capability clusters that are deemed to be required for successful technology innovation.
- 86 percent agreed (57% strongly agree plus 29% agree) that value realisation is one of the capability clusters that are deemed to be required for successful technology innovation.
- 89 percent agreed (53% strongly agree plus 36% agree) that integrative leadership is one of the capability clusters that are deemed to be required for successful technology innovation

These pilot survey results were interpreted as support for the initial innovation process and capability cluster assumptions made in Chapter 3. This field was retained in the main survey instrument as an additional source of data, should the main survey results differ from the pilot survey results. The main survey results, however, were very similar and are thus not further discussed.

6.2.2. Pilot survey results on capability clusters

Reliability analysis results of the six interim capability clusters with 60 behavioural items were above statistical threshold norms, as shown in Table 6.1.

Table 6.1: Summarised reliability analysis of constructs

Construct	Mean /50	Std. dev.	Valid n	Cronbach alpha	Standardised alpha	Av inter-item corr
Tech connectedness	41.04	5.50	52	0.87	0.88	0.43
Stakeholder alignment	36.90	5.73	52	0.90	0.90	0.52
Liberating mindsets	40.73	6.66	52	0.90	0.90	0.49
Value creation	41.52	5.68	52	0.89	0.89	0.48
Value realisation	40.23	6.62	52	0.91	0.91	0.52
Integrative leadership	46.85	6.43	52	0.91	0.92	0.51

As a measure of central tendency, the high means or average values of all six constructs exceeded 36, with integrative leadership being the highest at 46.85 (Bryman & Bell, 2011).

Standard deviation is a measure of dispersion that indicates the average amount of variation around the mean. It is calculated by taking the difference between each value in a distribution and the mean and then dividing the total of the differences by the number of values (Bryman & Bell, 2011:345). The pilot survey values were between 5.50 and 6.66.

Cronbach's alpha is a covariance measure of internal consistency of a measurement based on both the variance on the total measurement scores and the variances of the individual items (Welman, Kruger & Mitchell, 2012: 147). All scales were above 0.73, which suggests that the measure's constituent scales were internally reliable (Bryman & Bell, 2011:162).

Average inter-item correlation calculates the average of all the correlations between the items and is used to show how well a question discriminates between respondents. Values between 0 and 0.19 suggests poor discrimination, 0.2 to 0.39 is a good discrimination and values above 0.4 indicate very good discrimination. Consequently, this means that the pilot study values that are all above 0.4, fall into the very good discrimination category (Pope, 2016). All constructs measured in the pilot survey were in the very good discrimination category.

6.3. MAIN SURVEY RESPONSE RATE

The response rate of the snowball sampling over the duration of the data gathering is summarised in Table 6.2.

Table 6.2: Response rate analysis

SMS messages	email invites sent	email active	Opened questionnaires	Completed questionnaires
A	B	C	D	E
432	5 715	3 088	799	266
	Ratio B:A = 13.2	C/B = 54 %	D/C = 25.8 %	E/D = 33.29%

The SMS messages to 432 cell phone numbers resulted in 5 715 email invitations, of which 3 088 were identified as active based on return messages and bounced email messages received. Of the active email addresses, 799 (25.8%) questionnaires were opened of which 266 (33.29%) had been completed, resulting in an acceptable response rate (Bryman & Bell, 2011: 236).

While it was not possible to investigate reasons for non-completion due to the ethical considerations conveyed, the researcher's curiosity mentioned in Chapter 2 resulted in some reflection on possible reasons. Non-response is identified as a source of non-sampling error that tends to occur for many reasons, including sampled members refusing to cooperate, being unavailable, or for some reason unable to supply the data required (Bryman & Bell, 2011:176). This survey was anonymous, voluntary and confidential, which may have been sufficient reasons for some respondents to refrain from participating.

According to Bryman and Bell (2011:177), the problem with non-response is that it may include attitudes or patterns of behaviour. In this study, several factors observed by the researcher may have impacted negatively on actual participation rates, including regulatory, policy, technical and personal reasons that prevented eligible invitees from participating, as listed in Appendix J. Regulatory and policy reasons include respondent uncertainty about legislation and/or organisational terms and conditions for participating in academic surveys. A well-known South African business group, for example, made it clear that they had a policy against such participation. The CEO of a highly successful Stellenbosch Technopark-based enterprise completed the questionnaire, but made it clear in the submission covering note that they had been disappointed with other previous academic surveys that had been too theoretical to be of any value to those in practice. Technical reasons included server storage limitations, firewall and security protection mechanisms and email filters. Personal reasons included personal workload and time pressures as well as paradigm-related reasons revealed to the observer in survey-related conversations, such as deeply-held beliefs that innovation processes had to be separated from R&D processes, and that innovation had to be approached as a rational, linear, sequential process.

6.4. MAIN SURVEY DATA ANALYSIS AND INTERPRETATION

6.4.1. Sample demographics

Sample demographics were derived from responses received in the form of Excel spreadsheets produced by the Survey Administrator from 266 survey submissions by technology innovation leaders, who had achieved successful technology innovation and had been identified through peer-based snowball sampling across different technologies, industries, professions and organisations.

Initially, respondents had to complete all the survey fields for their responses to be saved as a response. However, when two respondents notified the researcher that they were reluctant to share any demographic information, the compulsory fields were replaced by voluntary capturing. As a result, 242 out of 266 survey responses included demographic data from which Table 6.3 was constructed as a summary, while a supporting range of graphic representations appear in Appendix K.

Table 6.3: Descriptive research results summary – n242

Demographic	Category	Salient results
Gender	Male	n186 (77%)
	Female	n56 (23%)
Age	Range	n242 aged between mid-20s to mid-70s n156 (68.6%) aged between 40 to 55 years
	Mean	49.08 years
Experience	Median	Median 14 years as technology innovation leader
Qualification	Post-graduate	78% (Honours = 12%; Masters = 42%, PhD = 24%)
Main discipline studied	Engineering	34%
	Business	24%
	Natural sciences	23%
Job focus	Senior management	47%
	Domain & technology specialist	33%
	Middle management	16%
Firm size	1 - 200	40.3%
	1000 – 3000+	43.4%
Firm type	Industry/SME	37%
	Research labs	35%
	Consulting	9%
	University	8.5%

6.4.2. Psychometric properties

The psychometric properties of the measurement instrument derived from the pilot survey were re-assessed to ensure reliability and validity, as represented in the sections that follow.

6.4.3. Reliability of constructs

Various techniques were used to analyse research data between and within the constructs of the survey instrument as indicated in Table 6.4. The reliability of the measurement items is shown in Table 6.5, Table 6.6, Table 6.7, Table 6.8, Table 6.9, Table 6.10, and Table 6.11. As composite reliability and Cronbach's alpha values of greater than 0.7 are deemed acceptable, all values appear excellent, which demonstrates measurement item reliability.

Table 6.4: Summarised reliability analysis of constructs

Construct	R	LCV	95% CI	Mean	Std. dev.	Valid n	Cron-bach alpha	Av Item corr
Success orientation	0.80	0.74	0.84	3.83	5.41	214	0.80	0.29
Technology connectedness	0.81	0.77	0.84	4.08	4.92	266	0.81	0.31
Stakeholder alignment	0.82	0.78	0.85	3.62	4.69	266	0.82	0.35
Liberating mindsets	0.87	0.86	0.91	4.00	6.09	266	0.89	0.44
Value creation	0.89	0.84	0.89	3.89	6.12	266	0.87	0.40
Value realisation	0.90	0.88	0.92	3.77	6.65	266	0.90	0.48
Integrative leadership	0.87	0.87	0.92	4.55	6.39	266	0.90	0.45

R values refer to the correlation coeficients with the items as predictors and the total score as the dependent variable.

LCV means lowest critical value which is the lower of the critical values depicting the range of scores within which R must fall to be at the 95% level of certainty. In the case of the Integrative leadership construct, for example, Alpha critical values are between 0.87 and 0.92 at the 95% confidence level, which is the Cronbach's alpha with a 95% confidence interval that ranges from 0.87 to 0.92. In all cases the reported R values are within calculated ranges and thus reliable at the 95% confidence interval level (Bryman & Bell, 2011).

As a measure of central tendency, the high means or average values of the constructs exceeded 36.18 with integrative leadership being the highest at 45.45 (Bryman & Bell, 2011). In the case of the integrative leadership construct, for example, the mean of 45.45 conincides with a standard deviation (Std. dev.) of 6.39 for the 266 (n266) responses calculated. Standard deviations as measures of dispersion indicate the average amount of variation around the mean that ranged between 4.69 and 6.65 for the survey constructs.

Cronbach's alpha is a covariance measure of internal consistency of a measurement based on both the variance on the total measurement scores and the variances of the individual items (Welman, Kruger & Mitchell, 2012: 147). All scales were above 0.79 which suggests that the measure's constituent scales were internally reliable (Bryman & Bell, 2011:162).

Average inter-item correlation refers to the average of all the correlations between the items. In the case of the integrative leadership construct, this average was 0.45, which is within the range of 0.15 to 0.50 that is considered as an acceptable level of consistency. Values between 0 and 0.19 suggest poor discrimination, 0.2 to 0.39 show good discrimination and values above 0.4

indicate very good discrimination (Pope, 2016). All other constructs performed within this range and are thus within acceptable levels of consistency.

In the remaining tables of this section, the first three data columns were included to show that the effect of deleting items had been tested which suggested that items had to be kept.

Item-Total correlation refers to the average of the correlations between the items and the total score for the measure. All these values are acceptable between 0.37 and 0.74. Squared multiple R indicates the correlations between actual and predicted values and, while acceptable values depend on the model complexity and the research discipline, 0.2 is acceptable in behavioural sciences (Hair Jr *et al.*, 2017: 198). With the exception of one item below 0.2 (0.19 in Table 6.9), all other values are between 0.27 and 0.63 and thus acceptable.

The last columns show the effects of Alpha being deleted, for which all reported values range between 0.77 and 0.90. These scores suggest sufficiently strong effects for none of the items to be dropped, and all items were thus retained.

6.4.3.1. Reliability analysis of success orientation

Table 6.5: Part 2 Q3: Success orientation

Alpha and 95% CI calculated in R=0.80 (0.74, 0.84) Summary for scale: Mean=38.25 Std.Dev.=5.41 Valid n: 214 Cronbach alpha: 0.80 Standardised alpha: 0.80 Average inter-item corr.: 0.29						
Variable	**Mean if deleted**	**Var. if deleted**	**StDv. If deleted**	**Itm-Totl Correl.**	**Squared Multp. R**	**Alpha if deleted**
Functionality	34.30	25.21	5.02	0.44	0.33	0.78
Productivity	34.48	23.95	4.89	0.51	0.40	0.77
Solution	33.94	25.64	5.06	0.43	0.25	0.78
Financial	34.44	24.22	4.92	0.50	0.45	0.78
Market	34.44	23.55	4.85	0.47	0.52	0.78
Venture	34.48	22.60	4.75	0.56	0.46	0.77
Human interface	34.71	23.90	4.89	0.51	0.33	0.77
Socio-economic	34.51	23.75	4.87	0.40	0.27	0.79
Skills	34.32	24.92	4.99	0.40	0.33	0.79
Radical	34.64	23.51	4.85	0.50	0.31	0.78

6.4.3.2. Reliability analysis of technology connectedness

Table 6.6: Part 3 Cluster 1: Technology connectedness

Alpha and 95% CI calculated in R=0.81(0.77, 0.84)
Summary for scale: Mean=40.83 Std.Dev.=4.92
Valid n: 266
Cronbach alpha: 0.81 Standardised alpha: 0 .81
Average inter-item corr.: 0.31

Variable	Mean if deleted	Var. if deleted	StDv. If deleted	Itm-Totl Correl.	Squared Multp. R	Alpha if deleted
TC_C1.1 CHNL_TC	36.67	20.18	4.49	0.53	0.36	0.79
TC_C1.2 XPRT_TC	36.61	20.08	4.48	0.51	0.37	0.79
TC_C1.3 TRCK_TC	36.83	19.71	4.44	0.55	0.36	0.79
TC_C1.4 CRED_TC	36.58	20.78	4.56	0.40	0.27	0.81
TC_C1.5 NTIC_TC	36.57	20.71	4.55	0.40	0.20	0.81
TC_C1.6 OPP_TC	36.75	20.88	4.57	0.37	0.29	0.81
TC_C1.7 PRTF_TC	36.77	20.33	4.51	0.43	0.34	0.80
TC_C1.8 SGNL_TC	36.62	19.84	4.45	0.55	0.37	0.79
TC_C1.9 PEST_TC	37.06	18.50	4.30	0.56	0.45	0.79
TC_C1.10 MODL_TC	37.03	18.60	4.31	0.63	0.47	0.78

6.4.3.3. Reliability analysis of stakeholder alignment

Table 6.7: Part 3 Cluster 2: Stakeholder alignment

Alpha and 95% CI calculated in R=0.82 (0.78, 0.85)
Summary for scale: Mean=36.19 Std.Dev.=4.70
Valid n: 266
Cronbach alpha: 0.82 Standardised alpha: 0.83
Average inter-item corr.: 0.35

Variable	Mean if deleted	Var. if deleted	StDv. If deleted	Itm-Totl Correl.	Squared Multp. R	Alpha if deleted
SH_C2.1 TRUST_SH	32.00	17.68	4.21	0.58	0.36	0.80
SH_C2.2 UNDST_SH	31.98	18.26	4.27	0.51	0.37	0.81
SH_C2.3 SUPP_SH	32.00	17.76	4.21	0.56	0.36	0.80
SH_C2.4 RES_SH	32.11	18.13	4.26	0.49	0.32	0.81
SH_C2.5 IMAG_SH	32.08	18.13	4.26	0.51	0.26	0.81
SH_C2.6 TALNT_SH	31.93	18.51	4.30	0.40	0.28	0.82
SH_C2.7 TENS_SH	32.46	16.94	4.12	0.58	0.40	0.80
SH_C2.8 GOV_SH	32.42	17.00	4.12	0.63	0.43	0.79
SH_C2.9 DESGN_SH	32.59	17.19	4.15	0.47	0.30	0.81

6.4.3.4. Reliability analysis of liberating mindsets

Table 6.8: Part 3 Cluster 3: Liberating mindsets

Alpha and 95% CI calculated in R=0.89 (0.86, 0.91)
Summary for scale: Mean=40.05 Std.Dev.=6.09
Valid n: 266
Cronbach alpha: 0.89 Standardised alpha: 0.89
Average inter-item corr.: 0.44

Variable	Mean if deleted	Var. if deleted	StDv. If deleted	Itm-Totl Correl.	Squared Multp. R	Alpha if deleted
LMS_C3.1 DIV_Column2	36.15	30.22	5.50	0.62	0.41	0.88
LMS_C3.2 ENGA_Column2	35.78	31.53	5.62	0.57	0.39	0.88
LMS_C3.3 PROV_Column2	35.85	30.29	5.50	0.62	0.45	0.88
LMS_C3.4 IDEA_Column2	35.96	30.08	5.48	0.65	0.51	0.87
LMS_C3.5 CAPT_Column2	36.23	29.76	5.46	0.71	0.51	0.87
LMS_C3.6 SOL_Column2	36.05	29.72	5.45	0.65	0.47	0.87
LMS_C3.7 CNSTR_Column2	36.01	29.89	5.47	0.68	0.49	0.87
LMS_C3.8 SPOT_Column2	36.28	29.78	5.46	0.65	0.48	0.87
LMS_C3.9 SHVAL_Column2	36.15	31.16	5.58	0.49	0.27	0.89
LMS_C3.10 CNTX_Column2	35.99	31.05	5.57	0.59	0.38	0.88

6.4.3.5. Reliability analysis of value creation

Table 6.9: Part 3 Cluster 4: Value creation

Alpha and 95% CI calculated in R=0.87(0.84, 0.89)
Summary for scale: Mean=38.98 Std.Dev.=6.12
Valid n: 266
Cronbach alpha: 0.87 Standardised alpha: 0.87
Average inter-item corr.: 0.40

Variable	Mean if deleted	Var. if deleted	StDv. If deleted	Itm-Totl Correl.	Squared Multp. R	Alpha if deleted
VC_C4: 1 PROT_Column2	34.96	32.85	5.73	0.40	0.19	0.87
VC_C4: 2 PERC_Column2	35.28	30.42	5.52	0.62	0.42	0.85
VC_C4: 3 SHFB_Column2	35.06	30.44	5.52	0.64	0.44	0.85
VC_C4: 4 DSTR_Column2	35.15	30.09	5.49	0.60	0.41	0.86
VC_C4: 5 SIMU_Column2	35.14	30.32	5.51	0.62	0.42	0.85
VC_C4: 6 CRIT_Column2	35.07	30.51	5.52	0.56	0.33	0.86
VC_C4: 7 IP_Column2	35.23	30.61	5.53	0.51	0.29	0.86
VC_C4: 8 TRLS_Column2	35.00	30.47	5.52	0.63	0.42	0.85
VC_C4: 9 COMM_Column2	35.02	29.39	5.42	0.68	0.51	0.85
VC_C4: 10 COLAB_Column2	34.92	31.08	5.58	0.61	0.43	0.86

6.4.3.6. Reliability analysis of value realisation

Table 6.10: Part 3 Cluster 5: Value realisation

Alpha and 95% CI calculated in R=0.90 (0.88, 0.92)
Summary for scale: Mean=37.66 Std.Dev.=6.65
Valid n: 266
Cronbach alpha: 0.90 Standardised alpha:0.90
Average inter-item corr.: 0.48

Variable	Mean if deleted	Var. if deleted	StDv. If deleted	Itm-Totl Correl.	Squared Multp. R	Alpha if deleted
VR_C5.1 MKT_Column2	33.98	36.70	6.06	0.57	0.42	0.90
VR_C5.2 HOLPR_Column2	33.95	36.08	6.01	0.64	0.50	0.89
VR_C5.3 MKTAL_Column2	33.98	35.04	5.92	0.71	0.58	0.89
VR_C5.4 FUD_Column2	34.03	35.44	5.95	0.67	0.55	0.89
VR_C5.5 AGIL_Column2	33.77	37.16	6.10	0.63	0.42	0.89
VR_C5.6 ECO_Column2	33.78	36.13	6.01	0.68	0.50	0.89
VR_C5.7 TTRAN_Column2	33.74	35.95	6.00	0.69	0.51	0.89
VR_C5.8 DEPL_Column2	34.00	36.09	6.01	0.71	0.54	0.89
VR_C5.9 PLTF_Column2	33.91	35.60	5.97	0.66	0.52	0.89
VR_C5.10 TSUPP_Column2	33.77	36.63	6.05	0.58	0.42	0.90

6.4.3.7. Reliability analysis of integrative leadership

Table 6.11: Part 3 Cluster 6: Integrative leadership

Alpha and 95% CI calculated in R=0.90 (0.87, 0.92)
Summary for scale: Mean = 45.46 Std.Dev.= 6.39
Valid n: 266
Cronbach alpha:0.90 Standardised alpha: 0.90
Average inter-item corr.: 0.45

Variable	Mean if deleted	Var. if deleted	StDv. If deleted	Itm-Totl Correl.	Squared Multp. R	Alpha if deleted
IL_C6.1 ROLE_Column2	41.20	36.16	6.01	0.45	0.27	0.90
IL_C6.2 VIS_Column2	41.19	35.10	5.92	0.58	0.39	0.89
IL_C6.3 ENG_Column2	41.42	34.01	5.83	0.61	0.44	0.89
IL_C6.4 EMP_Column2	41.24	33.58	5.79	0.69	0.54	0.88
IL_C6.5 MOTI_Column2	41.22	33.79	5.81	0.67	0.50	0.88
IL_C6.6 REC_Column2	41.45	33.98	5.83	0.58	0.44	0.89
IL_C6.7 FBAC_Column2	41.36	33.17	5.76	0.74	0.63	0.88
IL_C6.8 ENER_Column2	41.12	33.67	5.80	0.71	0.59	0.88
IL_C6.9 INTGR_Column2	41.38	33.36	5.78	0.68	0.54	0.88
IL_C6.10 FWRK_Column2	41.60	33.31	5.77	0.60	0.46	0.89
IL_C6.11 OWN_Column2	41.40	34.01	5.83	0.59	0.39	0.89

6.4.4. Two-dimensional scatterplots

Correlations were mapped of construct intersections as visual scatterplots of which some are presented in Figure 6.2 as evidence. An important requirement for using Pearsons's *r*, is that the relationship between two variables must be broadly linear and would thus, when values of the two variables are plotted on a scatter diagram, show an approximately straight line and not a curve (Bryman & Bell, 2011: 349). Correlations around 0.2 were considered low (Bryman & Bell, 2011: 349) and those above 0.50 were considered high (Pallant, 2001), which suggests their sufficiency as indicators of positive correlations.

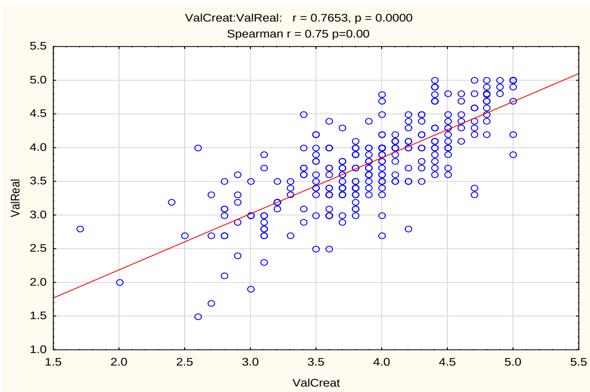


Figure 6: Value Creation : Value Realisation

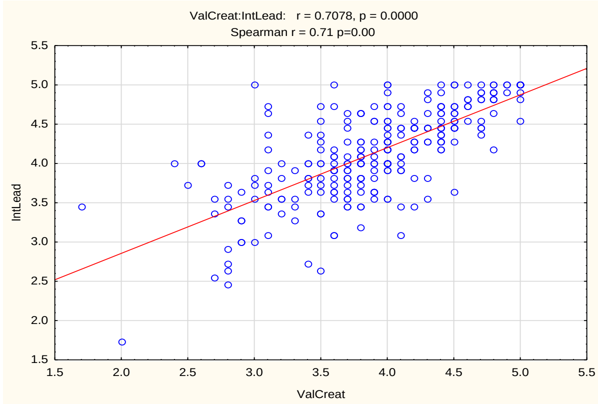


Figure 6: Value Creation : Integrative Leadership

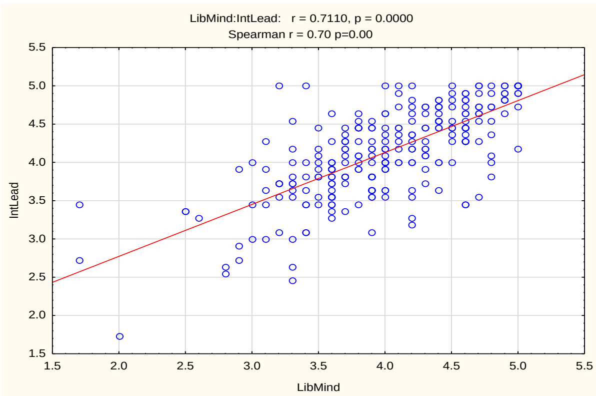


Figure 6: Liberating Minds Sets : Integrative Leadership

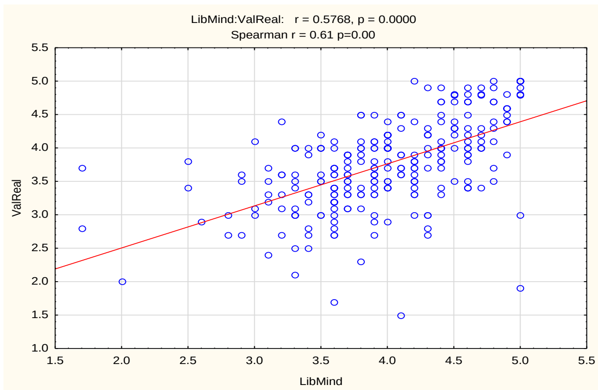


Figure 6: Liberating Mind Sets : Value Realisation

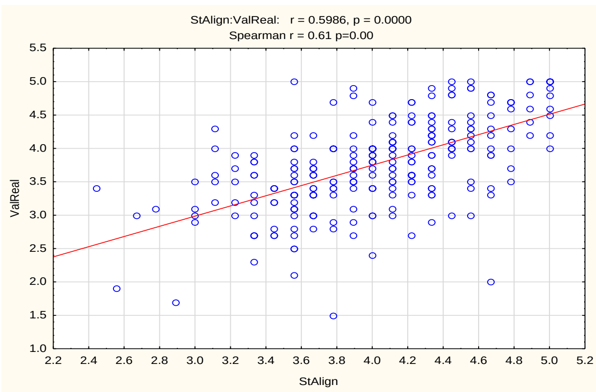


Figure 6: Stakeholder Alignment : Value Realisation

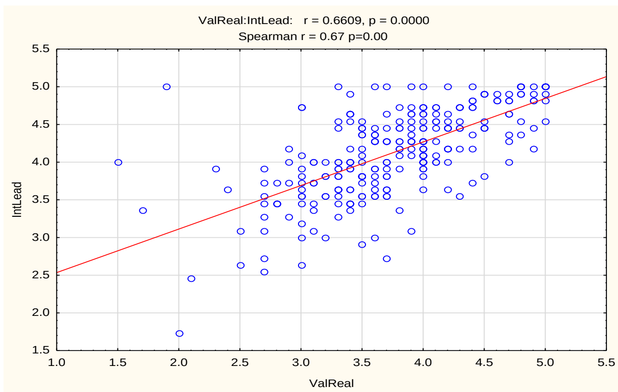


Figure 6: Value Realisation : Integrative Leadership

Figure 6.2: Scatterplots of some correlations

6.4.5. Summary of correlations

Table 6.12 shows Spearman's correlation matrix of r values (with p-values <0.01) for constructs summarised in a matrix format.

Table 6.12: Summary of Spearman values

Construct	Value	IL	LMS	SA	SO	TC	VC	VR
Integrative leader (IL)	Spearman r							
Liberate mindsets (LMS)	Spearman r	0.73						
Stakeholders alignment (SA)	Spearman r	0.66	0.61					
Success orientation (SO)	Spearman r	0.25	0.27	0.33				
Techno-Connectedness (TC)	Spearman r	0.60	0.62	0.64	0.36			
Value Creation (VC)	Spearman r	0.71	0.64	0.63	0.28	0.60		
Value Realisation (VR)	Spearman r	0.68	0.64	0.60	0.39	0.61	0.77	

The square value of Spearman *r* values provides a useful indicator known as a coefficient of determination, which expresses how much of the variation in one variable is due to the other variable (Bryman & Bell, 2011: 349). The lowest r value in Table 6.12 is Success Orientation: Integrative leadership at 0.25 and the highest r value is Value realisation: Value creation at 0.77. Both of these r values as well as the range of values between them are acceptable with 0.2 being low and 0.77 being high (Bryman & Bell, 2011:349).

6.4.6. Evaluation of the measurement model

A PLS-SEM analysis comprises of evaluating (i) the measurement model and (ii) the structural model to test the hypotheses (Hair Jr *et al.,* 2017). The following PLS-SEM quality criteria for a reflective measurement model assessment were used as a framework to evaluate the PLS-SEM model used in this study (Hair *et al.,* 2017:123). To assess the hypothecial model presented in Figure 4.11, the following perspectives are presented.

6.4.6.1. Internal consistency

Cronbach's alpha is a traditional criterion for internal consistency that provides an estimate of the reliability based on the intercorrelations of the observed indicator variables (Hair Jr *et al.,* 2017:111). All indicators are assumed equally reliable (i.e. all the indicators have equal outer loadings on the construct) by Cronbach's alpha, while PLS-SEM prioritises indicators according to their individual reliability. PLS-SEM justifies a technically more appropriate measure of internal consistency reliability known as "composite reliability" which ranges between 0 and 1 with higher values indicating higher levels of reliability (Hair Jr *et al.,* 2017:111). Composite reliability values of 0.60 to 0.70 are acceptable in exploratory research, while values between 0.70 and 0.90 can be regarded as satisfactory for confirmatory research. Values above 0.95 are not desirable because that may indicate that indicator variables are measuring the same phenomenon and therefore not likely to be a valid measure of the construct (Hair Jr *et al.,* 2017:112). Cronbach's alpha values are more conservative with lower reliability values, while composite reliability tends to overestimate internal consistency reliability resulting in comparatively higher reliability estimates with true reliability usually lying between these two values as was also found in this study as reported in Table 6.13 (Hair Jr *et al.,* 2017:111).

In Table 6.13 and similar tables in the rest of Chapter 6, the researcher applied the following interpretations to the columns. Original sample refers to the respective value (Cronbach alpha in the case of Table 6.13) calculated from the actual research data submitted, for which the corresponding sample mean and standard deviations were calculated. The *t* values represent the critical significance levels. When the size of an empirical *t* value is above 1.96, one can assume that the path coefficient is significantly different from zero, at a significance level of 5% in a two-tailed test, which was the case in all the tables presented. The *p* values represent the probability of obtaining an empirical *t* value at least as extreme as the one which is actually observed, if the null hypothesis is supported. A *p* value must be smaller than 0.05 at a significance level of 5% in order to render the relationship under consideration significant (Hair Jr *et al.,* 2017: 153). Calculations were also performed at 2.50% and 95% confidence interval levels, for which all values were accepted.

Table 6.13: Cronbach alpha reliability analysis of constructs

	Bootstrapping results					**Confidence intervals**		**Confidence intervals bias corrected**		
Con-struct	**Original sample**	**Sample mean**	**Std. dev.**	***t* values**	***p* values**	**2.50%**	**97.50%**	**Bias**	**2.50%**	**97.50%**
IL	0.89	0.89	0.01	70.06	<0.01	0.87	0.92	-0.001	0.87	0.92
LMS	0.89	0.88	0.02	56.21	<0.01	0.85	0.91	-0.001	0.85	0.91
SHA	0.79	0.79	0.02	36.80	<0.01	0.75	0.83	-0.002	0.75	0.82
SO	0.80	0.80	0.03	30.87	<0.01	0.74	0.84	-0.003	0.74	0.84
TC	0.79	0.79	0.02	34.48	<0.01	0.74	0.83	-0.002	0.74	0.83
VC	0.86	0.86	0.02	53.74	<0.01	0.82	0.89	-0.001	0.82	0.89
VR	0.90	0.89	0.01	67.24	<0.01	0.87	0.92	-0.001	0.87	0.92

The Cronbach alpha values and the composite reliability values reported thus strongly support high internal consistency of the constructs used in the PLS-SEM model.

6.4.6.2. Composite reliability of outer loadings

To evaluate reflective measurement models, estimates are required for the "relationships between reflective latent variables and their indicators (i.e. outer loadings)" (Hair *et al.,* 2017:124). Outer loadings presented in Table K.1 (in Appendix K, Section B) of the construct-indicator (item) relationships, 25 values are above 0.70 that indicates sufficient levels of indicator reliability (Hair *et al.,* 2017:124).

The box-and-whisker plot in Figure 6.3 indicates composite reliability values for all constructs to be above 0.7, which is the acceptable level (Bryman & Bell, 2011:345). Figure 6.3 shows both the central tendency (the median indicated by the bar) and the dispersion range (the highest and the lowest) in the I-shaped bar range (Bryman & Bell, 2011:345). The boxes indicate the middle 50% of responses. It can thus be concluded from Figure 6.3 that all the construct items in the PLS-SEM model were found to be reliable.

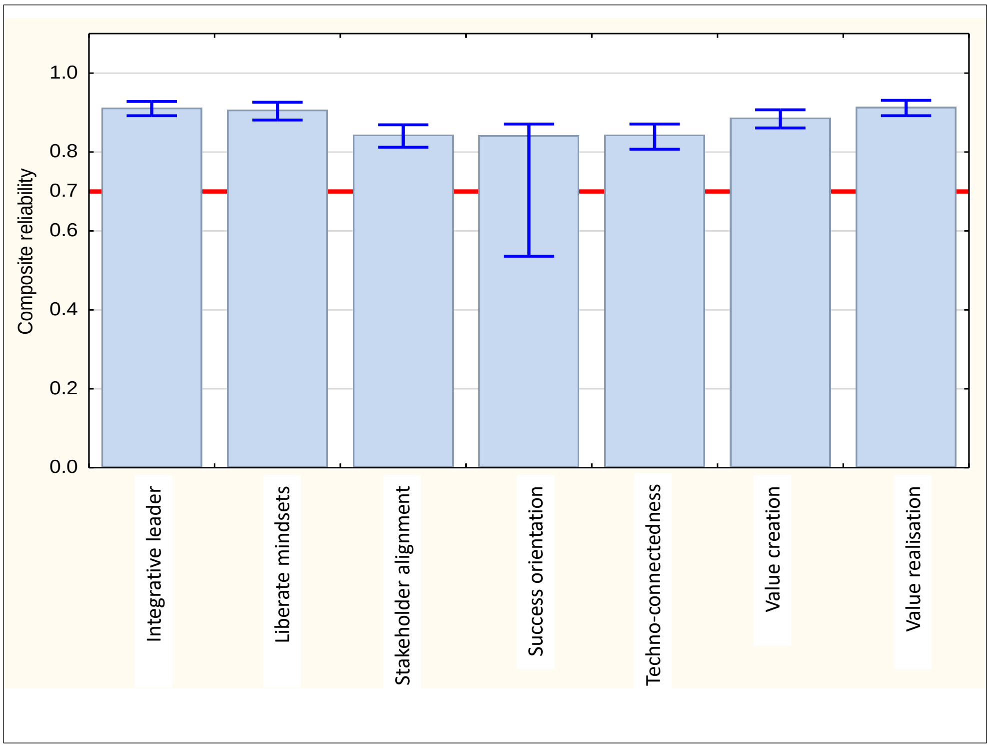


Figure 6.3: Composite reliability

Another 28 of the outer loadings in Table K.2a and Table K.2b (in Appendix K, Section B) have values of between 0.60 and 0.70, and 17 of the listed values are between 0.40 and 0.60. Hair Jr *et al.* (2017:113) provided a rule of thumb that the values of standardised outer loadings should be 0.708 or higher to achieve communality of an item. However, in social science studies, especially when new scales are used, outer loadings tend to be lower and values between 0.40 and 0.70 may be considered for removal from the scale if their removal increases the composite reliability or average variance extracted (AVE) which was not the case with calculations based on the sample data. All outer loading values in Table K.1 and Table K.2 (in Appendix K, Section B) were thus retained for this reason and also because all the listed values were found to be statistically significant at two confidence intervals (Kidd, 2016).

6.4.6.3. Average variance extracted (AVE)

The extent to which a measure correlates positively with alternative measures of the same construct is reflected in its convergent validity value derived from an evaluation of the outer loadings of the indicators (also known as indicator reliability) and the average variance extracted (AVE) where high values indicate that associated indicators have much in common which is captured by the construct (Hair Jr *et al.,* 2017:113).

Average variance extracted (AVE) is commonly used to establish convergent reliability on the construct level and an AVE value of 0.50 or higher indicates that, on average, the construct explains more than half of the variance of its indicators, while an AVE below 0.50 means that, on average, more variance remains in the error or items than the variance explained by the construct (Hair Jr *et al.,* 2017:114). Sample data in Table 6.14 shows AVE construct values of 0.50 and higher for two constructs, one is just below 0.5 at 0.49, while the remaining four constructs have AVE values below 0.50. The values suggest that the LMS and VR constructs explain more than half the variance of their indicators, while more variance remains in the error of the items than the variance explained by the construct in the remaining cases.

Table 6.14: Average variance extracted (AVE)

	Bootstrapping results					**Confidence intervals**		**Confidence intervals bias corrected**		
	Original sample	**Sample mean**	**Std.** dev**.**	***t* values**	***p* values**	**2.50%**	**97.50%**	**Bias**	**2.50%**	**97.50%**
IL	0.49	0.49	0.03	16.74	<0.01	0.43	0.55	0	0.44	0.55
LMS	0.50	0.49	0.03	14.91	<0.01	0.43	0.56	0	0.43	0.56
SHA	0.38	0.38	0.02	16.12	<0.01	0.33	0.43	0	0.33	0.43
SO	0.35	0.32	0.05	6.436	<0.01	0.17	0.41	-0.024	0.27	0.43
TC	0.36	0.36	0.03	14.55	<0.01	0.31	0.41	0	0.31	0.41
VC	0.44	0.44	0.03	16.61	<0.01	0.39	0.49	0	0.39	0.49
VR	0.52	0.51	0.03	16.62	<0.01	0.45	0.57	0	0.45	0.57

The box-and-whisker plot in Figure 6.4 indicates that AVE values for three of the constructs are below the ideal of 0.5. While stakeholder alignment and technology connectedness values are just below the 0.5 level, the success orientation construct is lower, which can be seen as a constraining factor in the model.

The box-and-whisker plot in Figure 6.4 indicates that AVE values for four of the seven differently configured constructs are at or above the threshold value of 0.5. While stakeholder alignment and technology connectedness values are just below the 0.5 level, the success orientation constructs (SO divided into three main components) are lower which can be seen as a constraining factor in the model, because only at the 0.50 level are reflective constructs acknowledged as having high levels of convergent validity.

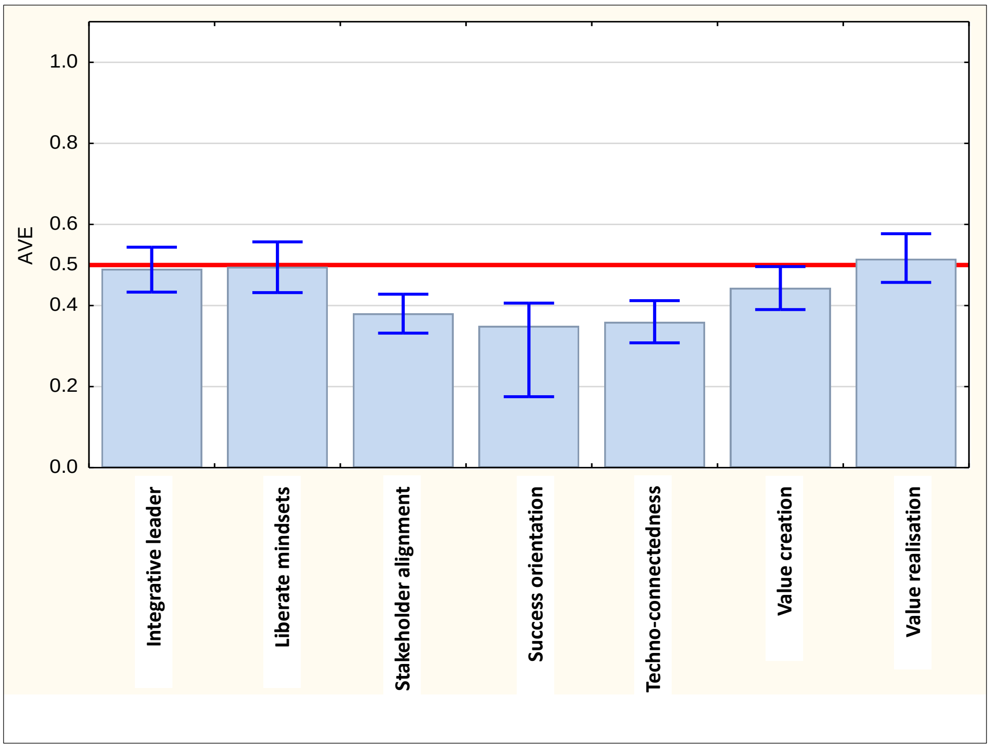


Figure 6.4: Reliability/outer model

As was done for composite reliability values above, AVE values were also recalculated after first removing outer values below 0.60 and then values below 0.70. While both AVE values and *t* values have increased marginally as a result, the corresponding changes in composite reliability did not improve convincingly and were interpreted as justification for keeping the model unchanged, particularly in light of the observation by Hair Jr *et al.* (2017:192) that PLS-SEM-based model fit measures were still in their early stages of development.

6.4.6.4. Discriminant validity

All the assessments discussed in Chapter 4 show sufficient discriminant validity in the sample data presented. Fornell-Larcker criterion discriminant validity is established when the square root of the AVE of each construct is higher than the construct's highest correlation with any other construct in the model, which is the case for most of the constructs in Table 6.15, except for the value creation (VC) construct, which at 0.67 is marginally below the value realisation (VR) construct at 0.75 (Hair Jr *et al.,* 2017:128).

Table 6.15: Fornell-Larcker criterion

	IL	LMS	SHA	SO	TC	VC	VR
IL	0.70						
LMS	0.67	0.70					
SHA	0.58	0.49	0.62				
SO	0.24	0.26	0.31	0.59			
TC	0.53	0.54	0.57	0.36	0.60		
VC	0.68	0.63	0.61	0.26	0.52	0.67	
VR	0.63	0.54	0.56	0.33	0.44	0.75	0.72

Discriminant validity is established when an indicator's loading on its assigned construct is higher than all of its cross-loadings with other constructs (Hair Jr *et al.,* 2017:118), which is the case with the sample data presented in Table K.3 of Appendix K. The Fornell and Larcker test for discriminant validity indicated that two of the latent variables, VC and VR, exhibit marginal discriminant validity issues. Therefore, it was decided to inspect the item correlation matrix again. This inspection revealed that one item cross-loaded and could be removed from the analysis. All the other items loaded as expected and the loading of VC items on the corresponding latent variable exceed the loadings of items of non-VC items. The same holds true for the VR latent variable. This situation suggests that discriminant validity is not problematic in this data set and the latent variables can all be assumed to exhibit sufficient discriminant validity.

While "frequently used in applied research, neither the Fornell-Larcker criterion nor the cross-loadings allow for reliably detecting discriminant validity issues" and another more reliable criterion, named the heterotrait-monotrait (HTMT) ratio should be applied (Hair *et al.,* 2017:129). The HTMT ratio is the mean of all correlations of indicators across constructs measuring different constructs relative to the mean of the average correlations of indicators measuring the same construct (Hair Jr *et al.,* 2017:118). The ratios reported on the sample data in Table 6.16 and Table 6.17 are all between 0.26 and 0.851, which are below the 0.90 ceiling value and below the 0.85 level above which constructs would lack discriminant validity. Therefore, it can be concluded that the constructs in this study meet the required discriminant validity levels.

Table 6.16: Heterotrait-monotrait (HTMT) ratios

	Bootstrapping results					Confidence intervals		Confidence intervals bias corrected			Dis-crimi-nate?
	Sam-ple	Mean	Std. dev.	*t* values	*p* values	2.50 %	97.50 %	Bias	2.50 %	97.50 %	
LMS -> IL	0.75	0.75	0.05	15.44	<0.01	0.65	0.84	0	0.64	0.84	Yes
SHA -> IL	0.68	0.68	0.09	7.32	<0.01	0.48	0.85	0.002	0.47	0.84	Yes
SHA -> LMS	0.57	0.58	0.09	6.68	<0.01	0.40	0.74	0.004	0.39	0.73	Yes
SO -> IL	0.26	0.31	0.07	3.66	<0.01	0.18	0.46	0.044	0.15	0.37	Yes
SO -> LMS	0.29	0.33	0.07	4.39	<0.01	0.22	0.48	0.041	0.17	0.39	Yes
SO -> SHA	0.39	0.42	0.07	5.58	<0.01	0.30	0.57	0.035	0.25	0.49	Yes
TC -> IL	0.62	0.62	0.09	6.71	<0.01	0.43	0.79	0.002	0.42	0.77	Yes
TC -> LMS	0.63	0.64	0.09	7.49	<0.01	0.46	0.79	0.005	0.44	0.77	Yes
TC -> SHA	0.73	0.73	0.08	9.33	<0.01	0.57	0.87	0.003	0.55	0.86	Yes
TC -> SO	0.45	0.48	0.07	6.82	<0.01	0.35	0.61	0.033	0.30	0.54	Yes
VC -> IL	0.76	0.76	0.05	16.79	<0.01	0.67	0.85	0	0.66	0.84	Yes
VC -> LMS	0.71	0.71	0.05	13.18	<0.01	0.60	0.81	0.001	0.59	0.81	Yes
VC -> SHA	0.74	0.74	0.07	10.70	<0.01	0.59	0.86	0.001	0.58	0.85	Yes
VC -> SO	0.32	0.35	0.07	4.37	<0.01	0.23	0.50	0.038	0.18	0.43	Yes
VC -> TC	0.62	0.62	0.08	7.76	<0.01	0.46	0.77	0.009	0.44	0.76	Yes

Table 6.17: Heterotrait-monotrait (HTMT) summary matrix

	IL	LMS	SHA	SO	TC	VC	VR
Integrative leadership (IL)							
Liberating mindsets (LMS)	0.76						
Stakeholder alignment (SHA)	0.66	0.57					
Success orientation (SO)	0.26	0.29	0.39				
Technology connectedness (TC)	0.62	0.63	0.73	0.45			
Value creation (VC)	0.76	0.71	0.74	0.32	0.61		
Value realisation (VR)	0.69	0.59	0.66	0.39	0.52	0.85	

6.4.6.5. Measurement model evaluation conclusion

As discussed in the preceding evaluation of the reflective measurement model used in this study, the high levels of meeting the model evaluation criteria provide support for the measure's reliability and validity (Hair Jr *et al.*, 2017:131).

6.4.7. Assessing PLS-SEM structural inner model results

As discussed in Chapter 4, PLS-SEM results are discussed next, based on a systematic approach derived from Hair Jr *et al.* (2017:190).

6.4.7.1. Path coefficients in the structural model

Significance and relevance of structural model relationships are reflected in path coefficients that have values approximately between -1 and +1, where values close to +1 represent strong relationships (Hair Jr *et al.,* 2017:194). Significance of path coefficients depends on its standard error that is obtained by means of bootstrapping, which allows the computing of *t* values and *p* values for all structural path coefficients, where a *t* value larger than the critical value is statistically significant at a certain error probability level (Hair Jr *et al.,* 2017:195).

A bootstrap distribution can be viewed as a reasonable approximation of an estimated coefficient's distribution in the population and its standard deviation can be used as proxy for the parameter's standard error in the population (Hair Jr *et al.,* 2017:152). Commonly applied "critical values for two-tailed tests are 1.65 (significance level = 10%), 1.96 (significance level = 5%), and 2.57 (significance level = 1%) (Hair Jr *et al.,* 2017:195).

When assuming a significance level of 5%, the *p* value must be smaller than 0.05 to conclude that the relationship being reviewed is significant at a 5% level (Hair Jr *et al.,* 2017:195). All the *p* values reported in Table 6.18 are below 0.05 and thus significant.

Based on the path coefficients shown in Table 6.18, the standard deviation *t* values, *p* values, and confidence levels, the relationships between the constructs are significant, except for the path coefficient between SO and ILO which is at 0.24.

Table 6.18: Structural model path coefficients

	Bootstrapping results					**Confidence intervals**		**Confidence intervals bias corrected**			**Significant from CI?**
	Sample β	**Sample mean**	**Std. dev.**	***t* values**	***p* values**	**2.50 %**	**97.50 %**	**Bias**	**2.50 %**	**97.50 %**	
IL -> LMS	0.68	0.68	0.04	15.19	<0.01	0.59	0.76	0.006	0.57	0.75	Yes
IL -> SHA	0.58	0.59	0.07	7.78	<0.01	0.43	0.72	0.01	0.40	0.70	Yes
IL -> TC	0.53	0.54	0.08	6.91	<0.01	0.38	0.68	0.013	0.34	0.65	Yes
IL -> VC	0.68	0.69	0.04	16.96	<0.01	0.60	0.76	0.007	0.58	0.75	Yes
IL -> VR	0.63	0.64	0.05	11.89	<0.01	0.53	0.73	0.007	0.50	0.72	Yes
SO -> IL	0.24	0.29	0.08	3.05	0.002	0.17	0.42	0.042	-0.34	0.33	Yes

Structural path coefficients can be interpreted relative to one another. This means that, if one path coefficient is larger than another, its effect on the endogenous latent variable is greater (Hair Jr *et al.,* 2017). A standard deviation change of the exogenous construct changes the endogenous construct by the size of the path coefficient when all other constructs and their path coefficients remain constant. Interpretation of path model results require testing of the significance of all structural model relations using *t* values, *p* values and the bootstrap confidence intervals (Hair Jr *et al.,* 2017:196).

The *t* values reported in Table 6.18 are all above the critical value of 0.975 computed at an alpha of 0.05, which means that a null hypothesis can be rejected in all cases. The *p* values are all below 0.05 which further justifies the rejection of the null hypothesis in all cases. The lowest path coefficient value is for the SO: IL path coefficient at 0.24 and a lower path coefficient of 0.17 at the 2.5% confidence level, but after correction for bias at the 97.5% confidence level, this 0.17 value changes to 0.33 as indicated in Table 6.18.

In addition to the reported significance of path coefficients, a researcher may also be interested in the indirect and total effects of one or more mediating constructs and total effects as reported in Table 6.19 and Table 6.20. Direct effects are relationships linking two constructs with a single arrow. An indirect effect refers to a sequence of two or more direct effects (compound path) that are represented visually by multiple arrows, as illustrated in Figure 6.5. The sum of direct and indirect effects makes up total effects (Hair Jr *et al.,* 2017: 197).

Table 6.19: Indirect effects

	Bootstrapping results					**Confidence intervals**		**Confidence intervals bias corrected**		
	Original sample	**Sample mean**	**Std dev.**	***t* values**	***p* values**	**2.50%**	**97.50%**	**Bias**	**2.50%**	**97.50%**
SO -> LMS	0.16	0.19	0.05	3.02	0.003	0.11	0.29	0.03	-0.25	0.22
SO -> SHA	0.14	0.17	0.06	2.49	0.013	0.08	0.28	0.03	-0.16	0.22
SO -> TC	0.13	0.16	0.06	2.32	0.02	0.07	0.27	0.03	-0.15	0.21
SO -> VC	0.17	0.19	0.05	3.05	0.002	0.12	0.29	0.03	-0.25	0.22
SO -> VR	0.15	0.18	0.05	2.92	0.004	0.10	0.28	0.03	-0.24	0.21

Hair Jr *et al.* (2017:198) regarded a direct effect of 0.20 as not very strong, while a total effect (the sum of direct and indirect effects) of 0.60 is described as “quite pronounced”, which includes the following total relationship effects in Table 6.20:

- Integrative leadership (IL) to liberating mindsets (LMS) is high at 0.68;
- Integrative leadership (IL) to value creation (VC) is high at 0.68;
- Integrative leadership (IL) to value realisation (VC) is high at 0.63.

The following two indirect effect values are just below, but still very close to the “quite pronounced” threshold value of 0.60 and can thus also be interpreted as strong:

- Integrative leadership (IL) to stakeholder alignment (SHA) is at 0.58;
- Integrative leadership (IL) to technology connectedness (TC) is at 0.53.

All the total effects relationships anchored in success orientation are at 0.24 or below, and thus not very strong, as indicated in Table 6.20 (Hair Jr *et al.,* 2017:198).

From the direct, indirect and total effects indicated in Table 6.18, Table 6.19 and Table 6.20 respectively, the direct effects between IL and LMS, IL and SHA, IL and TC, IL and VC as well as IL and VR, have the highest values. The direct effect between SO en IL, however, is at 0.24, which is described as not very strong (Hair Jr *et al.,* 2017: 198). Calculation of the total effects, by combining the direct and indirect effects, appear to make some difference in the *t* values but not the total effects. Therefore, it has to be acknowledged that the link between SO and IL appears to represent a relative weakness in the model, albeit not so weak that it can be discarded because it is above the 0.20 level.

Table 6.20: Total effects

	Bootstrapping results					**Confidence intervals**		**Confidence intervals bias corrected**		
	Original sample	**Sample mean**	**Std dev.**	***t* values**	***p* values**	**2.50 %**	**97.50 %**	**Bias**	**2.50%**	**97.50%**
IL -> LMS	0.68	0.68	0.04	15.19	<0.01	0.59	0.76	0.01	0.70	0.75
IL -> SHA	0.58	0.59	0.07	7.78	<0.01	0.43	0.72	0.01	0.40	0.70
IL -> TC	0.53	0.54	0.08	6.91	<0.01	0.38	0.68	0.01	0.34	0.65
IL -> VC	0.68	0.68	0.04	16.96	<0.01	0.60	0.76	0.01	0.58	0.75
IL -> VR	0.63	0.64	0.05	11.89	<0.01	0.53	0.73	0.01	0.50	0.72
SO -> IL	0.24	0.29	0.08	3.06	0.002	0.17	0.42	0.04	-0.34	0.33
SO -> LMS	0.17	0.19	0.05	3.02	0.003	0.11	0.29	0.03	-0.25	0.22
SO -> SHA	0.14	0.17	0.06	2.49	0.013	0.08	0.28	0.03	-0.16	0.22
SO -> TC	0.13	0.16	0.06	2.32	0.02	0.06	0.27	0.03	-0.15	0.21
SO -> VC	0.17	0.19	0.05	3.05	0.002	0.11	0.29	0.03	-0.25	0.22
SO -> VR	0.15	0.18	0.05	2.92	0.004	0.10	0.28	0.03	-0.24	0.21

6.4.7.2. Coefficients of determination (R^2 values)

The coefficient of determination (R^2 value) is used as a measure of the model's predictive power and is calculated as the squared correlation between a specific endogenous construct's actual and predicted values (Hair Jr *et al.,* 2017:198). R^2 values range from 0 to 1 with higher levels indicating higher predictive accuracy depending on the complexity of the model and the discipline. This explains why 0.20 R^2 values are considered high in behavioural studies (Hair Jr *et al.,* 2017:198). A value of 0.06 would be at the lower end, but still acceptable as discussed under Figure 6.5.

Hair Jr *et al.* (2017:199) warned against using R^2 values reported in Table 6.21 and Table 6.22 as the only basis for understanding a model's predictive power because it contains an inherit bias towards models with many exogenous constructs. Consequently, researchers may prefer models with fewer exogenous constructs that are good at explaining the data, also known as parsimonious models. The adjusted coefficient of determination values in Table 6.22 can be used to avoid bias towards complex models (Hair Jr *et al.*, 2017:199).

Table 6.21: Coefficients of determination (R^2 values)

	Bootstrapping results					Confidence intervals		Confidence intervals bias corrected		
	Original sample R^2	Sample mean	Std dev.	*t* values	*p* values	2.50 %	97.50%	Bias	2.50 %	97.50%
IL	0.06	0.08	0.03	1.56	0.119	0.03	0.17	0.02	0.01	0.10
LMS	0.46	0.46	0.06	7.59	<0.01	0.34	0.58	0.01	0.32	0.55
SHA	0.33	0.35	0.08	3.88	<0.01	0.18	0.51	0.01	0.16	0.49
TC	0.28	0.29	0.08	3.43	0.001	0.14	0.45	0.02	0.11	0.42
VC	0.46	0.47	0.05	8.44	<0.01	0.36	0.57	0.01	0.34	0.55
VR	0.40	0.40	0.06	5.94	<0.01	0.27	0.53	0.01	0.25	0.51

Table 6.22: Coefficients of determination (R^2 adjusted values)

	Bootstrapping results					Confidence intervals		Confidence intervals bias corrected		
	Original sample R^2	Sample mean	Std dev.	*t* values	*p* values	2.50%	97.50 %	Bias	2.50%	97.50 %
IL	0.06	0.08	0.03	1.43	0.151	0.02	0.17	0.02	0.01	0.10
LMS	0.46	0.46	0.06	7.52	<0.01	0.34	0.57	0.01	0.32	0.55
SHA	0.33	0.34	0.08	3.83	<0.01	0.18	0.51	0.01	0.15	0.48
TC	0.28	0.29	0.08	3.37	0.001	0.13	0.45	0.02	0.11	0.42
VC	0.45	0.46	0.05	8.36	<0.01	0.36	0.57	0.01	0.33	0.55
VR	0.39	0.40	0.06	5.87	<0.01	0.27	0.53	0.01	0.24	0.51

The hypothetical model in Figure 4.11 can now be populated with sample data to present a statistical reflective PLS-SEM model as conveyed in Figure 6.5 and Figure 6.6 from which the following interpretations can be derived:

i) The success orientation of the leader influences the integrative leadership competencies of the leader;

ii) The integrative leadership competencies of the leader influence five other leader competencies as follows:

- Technology connectedness of the leader;
- Stakeholder alignment competencies of the leader;
- Liberating mindsets competencies of the leader;
- The value creation competencies of the leader;
- The value realisation competencies of the leader.

6.4.7.3. Hypotheses test results as a statistical model

Figure 6.5 conveys the statistically-derived model depicting the relationship between success orientation and technology innovation leader competencies for successful technology innovation.

Statistical testing was conducted to determine whether sufficient evidence was drawn from the test sample to infer that a hypothetical condition is true for an entire population. The values inside the circles indicate the R^2 values for co-variance on latent item variables and these are also shown in Table 6.18 as at two confidence intervals at *p* values of <0.01. The path coefficiency values indicated on the connecting lines of the statistical model are similar to the beta-coefficients used in a regression analysis and reflect positive directional probabilities of six hypothetical claims posed in Chapter 5 from which the following claims are derived:

H_1 : The null hypothesis is rejected in favour of the alternative hypothesis based on a value of 0.24 which, according to Pallant (2001) is low but sufficient. The success orientation of a technology innovation leader has a relationship with the integrative leadership of a technology innovation leader, albeit at a lower level than was found in the other hypothesis. Babbie and Mouton (2008: 82) emphasised that “a perfect correlation between variables is not a criterion of causality...” and, that exceptions that “...do not prove the rule, do not necessarily deny the rule either”. The hypothesised relationship was measured between success orientation as independent variable and integrative leader competencies as dependent variable (Zikmund, 2013). Zikmund (2013) also proposed the use of extraneous variables, as variables other than the independent variable that influence the dependent variable, tend to lead to noise but do not systematically bias the results.

H_2 : The null hypothesis is rejected in favour of the alternative hypothesis based on a value of 0.53 which, according to Pallant (2001) is high. The integrative leadership of a technology innovation leader has a relationship with the technology connectedness competencies of a technology innovation leader.

H_3 : The null hypothesis is rejected in favour of the alternative hypothesis based on a value of 0.58 which, according to Pallant (2001) is high. The integrative leadership of a technology innovation leader has a relationship with the stakeholder alignment competencies of a technology innovation leader.

H_4 : The null hypothesis is rejected in favour of the alternative hypothesis based on a value of 0.68 which, according to Pallant (2001) is high. The integrative leadership of a technology innovation leader has a relationship with the liberating mindsets competencies of a technology innovation leader.

H_5 : The null hypothesis is rejected in favour of the alternative hypothesis based on a value of 0.68 which, according to Pallant (2001), is high. The integrative leadership of a technology innovation leader has a relationship with the value creation competencies of a technology innovation leader.

H_6 : The null hypothesis is rejected in favour of the alternative hypothesis based on a value of 0.63 which, according to Pallant (2001) is high. The integrative leadership of a technology innovation leader has a relationship with the value realisation competencies of a technology innovation leader.

The statistical model in Figure 6.5 shows convincingly strong path coefficients for the relationships between integrative leadership and the other constructs (TC, SHA, LMS, VC and VR). The R-squared values are equally convincing for these constructs. The path coefficient for the relationship between success orientation and integrative leadership clusters in the model is less strong, but still acceptable at above 0.2 level.

The weakness of the model in Figure 6.5 is the R-squared value of integrative leadership, which is at 0.06, which is low but not low enough to reject the model. Based on the research data, only six percent of the variances in integrative leadership are explained, which suggests that factors other than integrative leadership may have to be investigated for a better understanding.

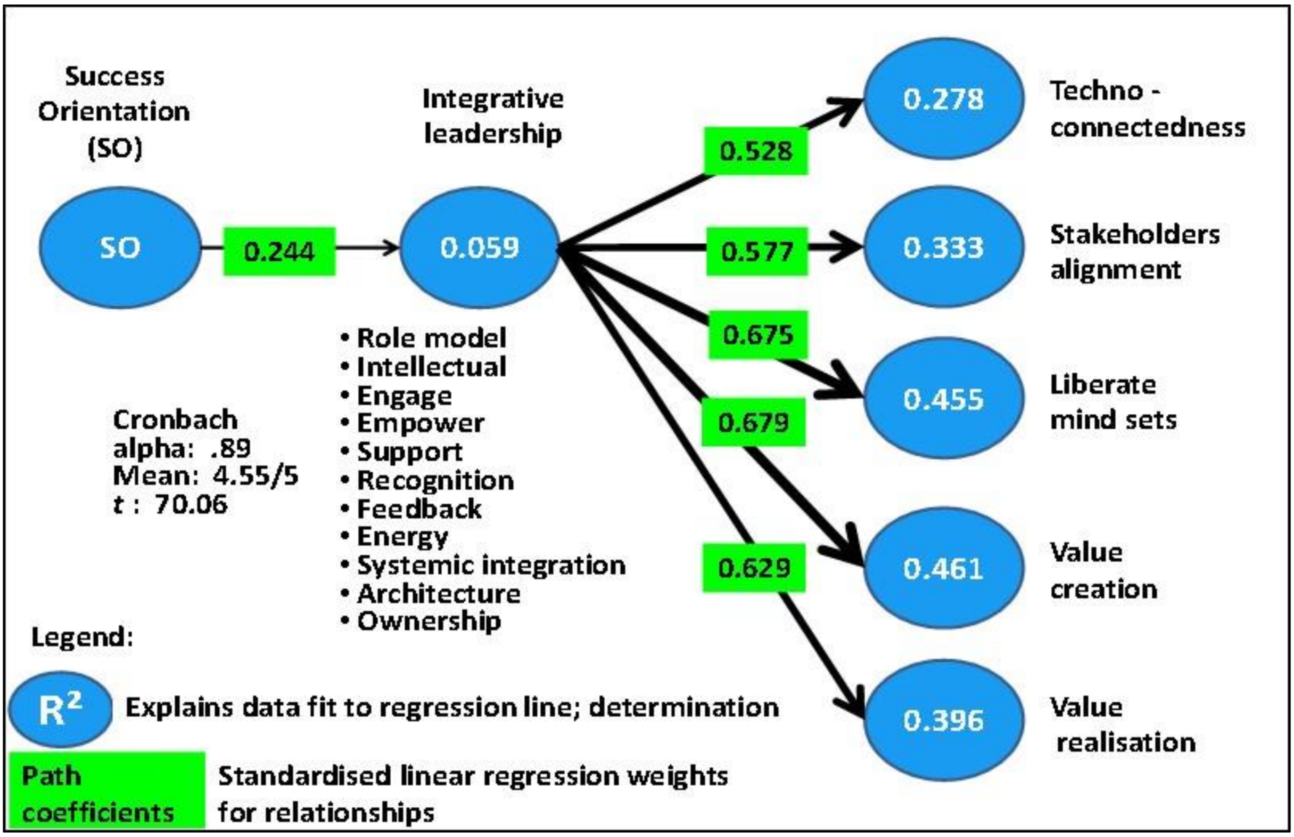


Figure 6.5: Statistical model depicting relationship between success orientation and technology innovation leader competencies for successful technology innovation

Figure 6.6 graphically displays the complete PLS-SEM model with only *t* values included to give the reader a visual impression of how the model elements articulate. A path diagram is used to depict the relationships between constructs in a model (Hair, Black, Babin, Anderson & Tatham, 2006: 878). Figure 6.6 conveys a visual representation of the complete PLS-SEM model in which all the *t* values exceed the threshold values of normal Gaussian quantities (Hair Jr *et al.,* 2017: 153).

The coefficient of 0.24 between success orientation and integrative leadership suggests that the influence of success orientation on integrative leadership is positive but not strong. No single data set could be used to explain this relatively low coefficient and further research is required. What may be relevant is that, during the expert interviews and workshops, comments were made about the near impossible expectations that stakeholders sometimes have of technology innovation, such as delivering technology innovations for competitiveness, economic growth, job creation, people benefits and radical innovation at the same time.

The path coefficients between integrative leadership and the other five constructs showed values between 0.53 and 0.68, which are all significant relationships, the highest being integrative leadership and value creation, which is a significant revelation because of its potential implications on current practices.

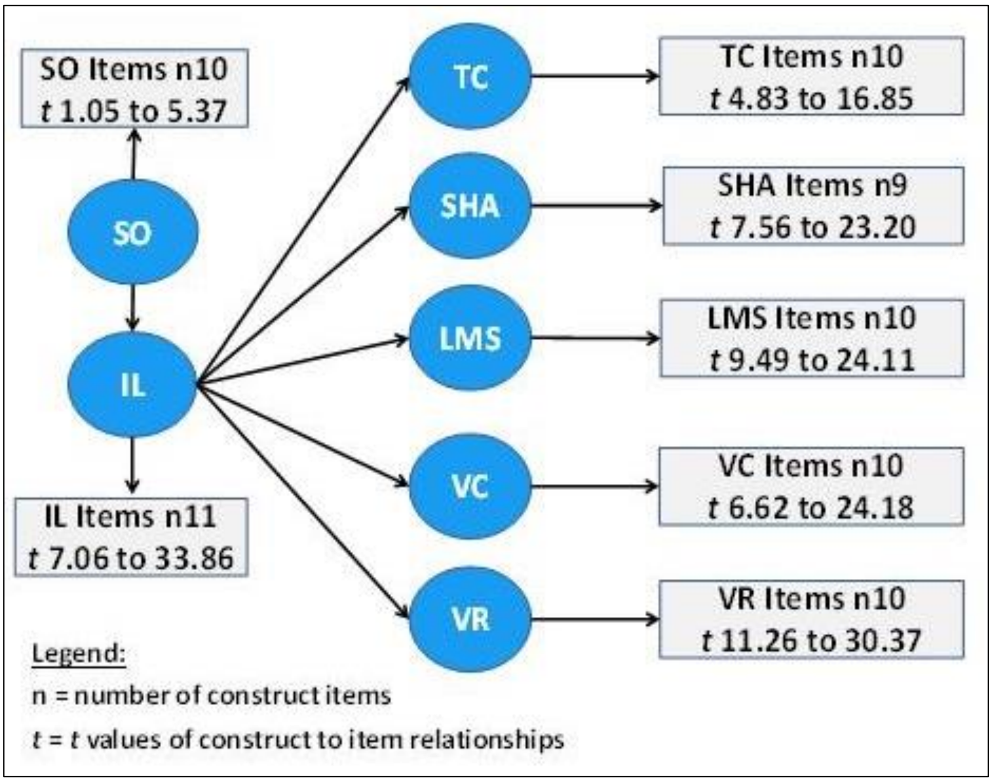


Figure 6.6: Illustrative complete PLS-SEM statistical model depicting *t* values of relationships between constructs and their items

6.4.7.4. The f^2 effect size

Changes in R^2 values brought about by omitting exogenous constructs from a model can be used as an additional evaluation of the impact of a construct on endogenous constructs as measured by the f-squared effect size (Hair Jr *et al.,* 2017:201). Hair Jr *et al.* (2017:201) provided guidelines for assessing f-squared values (f^2) whereby values of 0.02, 0.15, and 0.35 respectively represent small, medium and large effects of the exogenous latent variable.

Except for the success orientation (SO) to integrative leadership (IL) value which is small at 0.06, all the f^2 values in Table 6.23 are above 0.35, which suggests that those f^2 values in the model are large. Such large values mean that their effects are significant with the effect of integrative leadership (IL) on value creation (VC) being the highest at 0.86 and its effect of liberating mindsets (LMS) also very high at 0.84.

Table 6.23*: f* Square

	Bootstrapping results					Confidence intervals		Confidence intervals bias corrected		
	Original sample f^2	**Sample mean**	**Std dev.**	***t* values**	***p* values**	**2.50 %**	**97.50 %**	**Bias**	**2.50%**	**97.50 %**
IL -> LMS	0.84	0.89	0.21	3.83	<0.01	0.52	1.38	-0.15	0.48	0.48
IL -> SHA	0.50	0.56	0.21	2.29	0.022	0.22	1.06	0.08	0.28	0.56
IL -> TC	0.38	0.44	0.17	2.21	0.027	0.16	0.84	0.15	0.23	0.39
IL -> VC	0.86	0.91	0.20	4.21	<0.01	0.56	1.36	-0.17	0.54	0.54
IL -> VR	0.65	0.70	0.19	3.32	0.001	0.38	1.15	-0.01	0.56	0.75
SO -> IL	0.06	0.09	0.04	1.32	0.186	0.03	0.21	0.22	-0.39	-0.27

6.4.7.5. Interpretation of PLS-SEM results

From the data and analyses presented in the preceding discussion, it appears that:

- The measurement model adequately meets the requirements for validity and reliability; and
- The PLS-SEM analyses of research results have been successfully evaluated.

The emergent model may thus be described as an “integrative innovation leadership model” that coherently links the technology innovation leader competencies deemed to be required for successful technology innovation, thereby answering the research question and providing a theoretical model that may hold developmental and performance benefits.

6.4.8. Research reflections on statistical results

Salient observations drawn from the findings and analyses presented in this chapter are summarised in Table 6.24.

Table 6.24: Summarised salient interpretations from analyses of quantitative results

Researcher interpretations	Evidence
Technology innovation processes that were used by successful technology innovation leaders in practice appear **not to be complying with linear sequential process models** and their underlying assumptions, except for processes based on the laws of nature.	Section 6.2
Processes used by successful technology innovation leaders appear to be more accommodating to allow for changing conditions than with the **leader competencies being applied in a sequence required to make overall progress,** rather than adhering to a detailed plan.	Section 6.2
Six technology **innovation leader competencies** as well as their underpinning leader behaviours as identified and described were statistically tested yielding statistically-significant results.	Section 6.2
The **integrative leader competency appears critical** for technology innovation success through energising, systemic integration of technical, human and business elements, guiding innovation frameworks and instilling a sense of collective identity among team members. Results also appear consistent with other transformational leadership studies in terms of the significance of role-model, vision, engagement, empowerment, motivation, appreciation and providing constructive timely feedback elements of the construct.	Highest construct mean ratings in Table 6.1
The **stakeholder alignment** competency appears not to have been included in other innovation leadership studies, but was found to be a significant competency in achieving successful technology innovation with its mean rating of 36.9 on a five-point scale.	Table 6.1
Technology connectedness as a competency was deemed to be required for successful technology innovation and appear not to have been covered by other studies. Particular emphasis was placed by experts as well as technology innovation leaders, on the **credibility** of the leader, both technical and business.	Third highest mean ratings in Table 6.1
The **liberating mindsets** competency entails more than idea generation as a phase in technology innovation and may be required throughout the innpovation process where original thinking was constrained by outdated mental models or paradigms.	Fourth highest mean ratings in Table 6.1
The relationships between constructs of the hypothetical **model meet the statistical requirements for a reflective PLS-SEM model** and can thus be used for theory development.	Figure 6.5 Figure 6.6
With the **statistical model** emerging from the hypothesised model, this research offers a structural foundation for future research as it structures the capability clusters of leadership and indicates relationships.	Figure 6.5 Figure 6.6
The **relationship between success orientation (SO) and integrative leadership showed a lower path coefficient than any other relationship** in the emergent PLS-SEM model, yet it is still statistically significant. The research data gathered does not adequately reveal causes, but from qualitative research data and feedback received, it appears that respondents found the spectrum of success indicators more challenging than previously acknowledged, particularly in light of changing priorities and fluctuating resourcing. The study also did not cover to what extent success elements featured prior to agreement on performance metrics or afterwards.	Figure 6.5

The results of Chapter 6 confirmed that the technology innovation leader competencies deemed to be required for successful technology innovation had been correctly identified from the inputs of technology innovation leaders in Chapter 5, and deemed to be significant in Chapter 6.

The relationships between and within identified leader competencies provide new insights into how these variables interact in practice, from which benchmarking and other comparative analyses become possible.

What stood out for the researcher in the integrative leader competency behaviours, was the high ratings given by respondents for technology innovation leader behaviours related to feedback and positive innovation energy. The positive innovation energy competency has not previously been included in studies of this nature.

The propositions implied in the provisional conceptual model in Figure 1.6 were thus found to be statistically verified in the hypothesised relationships shown in the theoretical framework in Figure 3.32. The hypotheses formulated in Section 4.11 were thus all accepted.

6.5. CHAPTER CONCLUSION AND SYNTHESIS

This chapter further explored the epistemological foundations for a study into the technology innovation leader competences deemed to be required for successful technological innovation. It was pointed out, in previous chapters, that the scholarly body of knowledge would benefit from new thinking about the leader competencies involved, as well as new theoretical perspectives on their intra- and interrelationships.

From the material reviewed, and the interim capability clusters defined and populated during the qualitative research phase, as discussed in Chapter 5, the concept, constructs and items were subjected to quantitative empirical measurement in Chapter 6. As a result, the provisional conceptual model presented in Chapter 1, in which proposed relationships between variables were hypothesised, was tested and found to be statistically significant.

The research question underpinning this study directed research effort into answering the question: “What technology innovation leader competencies are deemed to be required for successful technology innovation?” As envisaged in the conceptual model in Figure 1.6, it can now be concluded that the research question had been answered. A total of six competencies and their underpinning behyaviours have been identified and statistically tested to yield statistically-significant results.

The relationships in the hypothesised integrative innovation leadership model were all found to meet the threshold statistical values. The one exception in the model is the relatively weak relationship between success orientation of the leader and the integrative leader competency of the leader, while all the subordinate realtionships delivered values higher than the threshold values. While the data does not explain the weak relationship, it can be assumed that factors other than the leader's competencies had played a role.

A synthesis can be seen as a combination of components to represent a whole, which in this study included a conceptual model, a theoretical framework and a methodological framework (Arksey & O'Malley, 2002). These frameworks were developed and applied to answer the main research question and address the main aim of the study (Bryman & Bell, 2011:681).

The analysis of research data from both research phases provided new insights into the leader competencies deemed to be required for successful technology innovation and how they relate statistically, which had not been done before. As a result of these insights, the next step of insight is discussed in the concluding chapter from an improved basis of knowing. 'Knowing', in this sense refers to the doctorateness framework introduced in Chapter 1 which contains 12 components or portals that can be seen as thresholds of knowing, clustered around the concept of synergy (Trafford & Leshem, 2009).

CHAPTER 7

SUMMARY, INTEGRATION AND CONCLUSION

7.1. CHAPTER INTRODUCTION

The aim of this study was to identify technology innovation leader competencies deemed to be required for successful technology innovation. Figure 7.1 shows elements and key messages from this chapter's reflection on the results of this study through summaries, discussions, interpretations and where appropriate, recommendations for further research related to findings, claims, the competency profile and broader significance of findings reported in the previous chapters. This chapter integrates the research work and draws the research process to a conclusion.

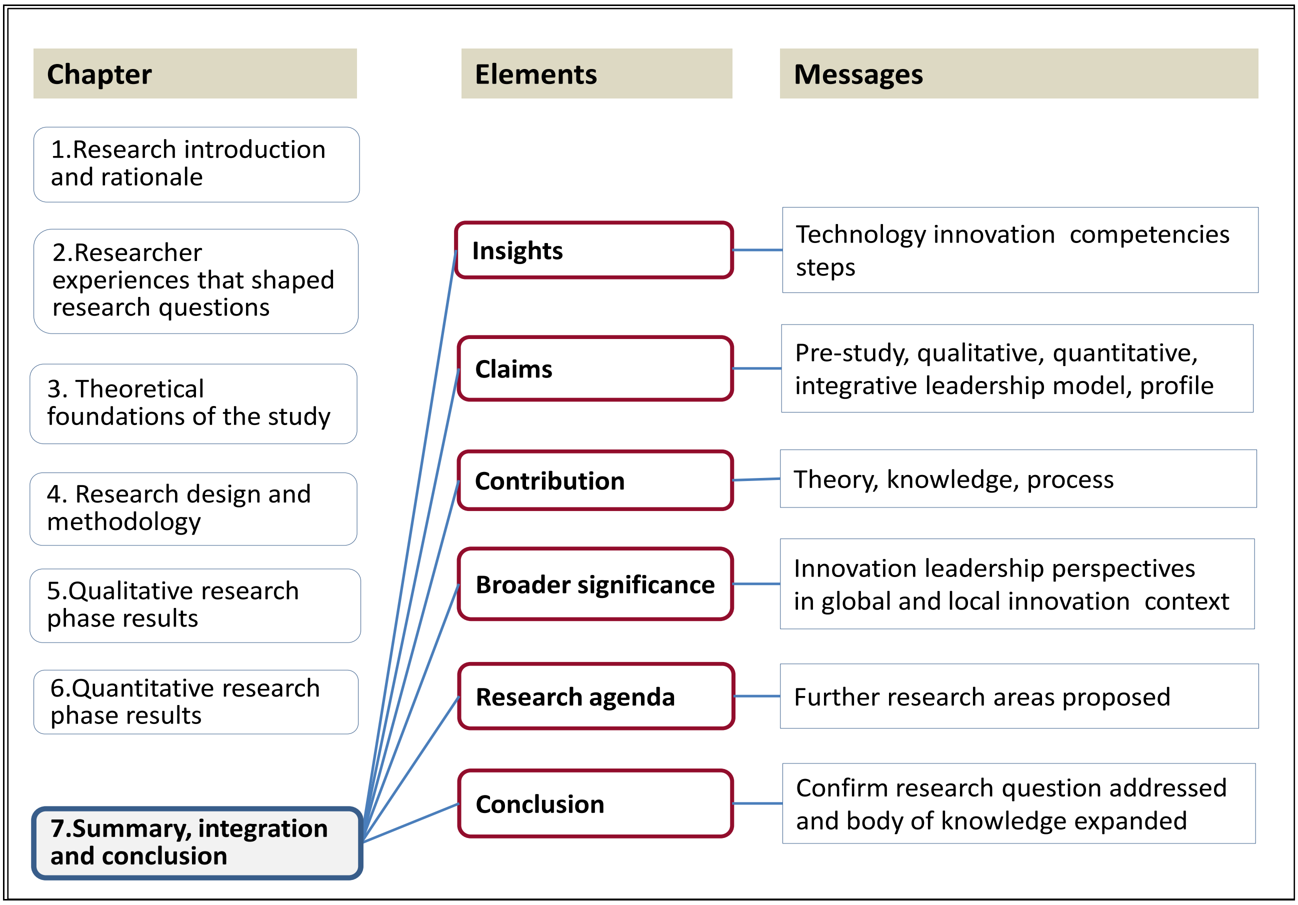


Figure 7.1: Thesis map of Chapter 7

7.2. INSIGHTS FROM THE STUDY

7.2.1. Personal reflections

During the study, the knowledge gap discussed in Chapter 3 emerged as a universal challenge, rather than only a South African challenge. It became clear that technology innovation is inextricably linked to global trends, networks and knowledge. Scholarly contributions from different disciplines and the research data allowed a better understanding of technology innovation leader competencies that evolved throughout the study, as reflected in Table 7.1.

Table 7.1: Thesis steps to identify and confirm technology innovation leader competencies

Thesis section	Discussion	Aggregated insights
3.6.4	A linear sequential four-stage innovation process (Swart, 2013) was deconstructed into process elements across process models to identify leader competencies (Table 3.5)	Process elements can be arranged to fit process models presented
3.6.4	Technology innovation views of McAdam and McClelland (2002:91) were re-introduced into an extended version of the four-stage innovation process of Swart (2013)	Idea generation was strongly connected to prior knowledge generation and R&D in their original research
3.6.4	The four-stage process model was expanded into seven (later six) interim capability clusters to guide identification of technology innovation leader competencies (Table 3.6)	The interim capability clusters compensate for the lack of technology innovation process for technology innovation
3.7	A theoretical framework was compiled from multiple theories to respond to the knowledge gap and guide research design and methodology selection (Figure 3.33)	Multiple theoretical perspectives stimulate and direct research thinking
3.9.4	The interim capability clusters were updated and reworded from reviews of theories	Descriptions of interim capability clusters enhance understanding
4.6.5 5.2.5	The research data sources were triangulated (experts, workshop with technology innovation leaders, case materials and literature search)	Technology connectedness and stakeholder alignment capabilities have been underemphasised in process models
4.6.6 5.2.6	The qualitative research data was coded for content analysis towards competency identification	The interim capability clusters would be adequate to initiate early coding of data
5.2.7	The innovation process views were synthesised to review the interim capability clusters to serve as research themes	Improved, revised wording of the interim capability clusters provides clarity of the research themes
5.4	The innovation leadership competency perspectives were reviewed to understand what is required to address the knowledge gaps	Understanding multiple perspectives influences competency identification
5.4	The research themes were populated with behaviours from research data to describe sets of leader behaviours	Sets of leader competencies are based on behavioural items
5.5	Emerging elements of a technology innovation leadership theory based on capability clusters were updated by applying the research themes	Interim technology innovation capabilities might interrelate and intercorrellate as constructs
5.6	Pre-quantitative phase reflections (Table 5.10)	The identified capabilities are also found in biographies of a famous technology innovator leader
4.11 6.4.7	The hypothetical model was supported by the statistical model through statistically-significant data	The research question is answered. The findings are suitable for competency profiling

Some personal reflections were presented to convey the researcher's perspectives on insights and findings presented. In this reflection, the researcher deliberately used "to some extent" as a qualifier. Current research practices and technologies are still limited in what they allow the scholar to observe and measure. The researcher's own experiences of working with successful technology innovation leaders, as discussed in Chapter 2, suggest that the identified competencies in which the researcher recognises all three of the following statements, would be found to be true for most successful technology innovations. Perhaps technology leaders who are able to integrate these competencies would also be able to lead new technology innovations to take the results of this study into a next research paradigm (Kuhn, 1962).

To some extent the following statement conveyed the essence of identified technology innovation leader competencies that may not have been fully captured in this thesis:

> *...successful innovation teams are more likely to be those that combine a dense set of internal linkages, which facilitates trust, consensus, and efficient and effective internal team communication, with an open network linking the team members to a variety of external sources, and which expose the team to in-flows of new ideas and information* (Conway & Steward, 2009:303).

To some extent, the following statement by Janssen (cited by Grobler, 2016) conveyed the essence of the success orientation of successful technology innovation leaders that differentiates them from other leaders:

> *Innovation can be defined as the intentional generation, promotion, and realization [sic] of new ideas within a work role, group or organization [sic], in order to benefit role performance, the group, or the organization [sic]... According to this definition, individuals and groups undertake innovative activities from the intention to derive anticipated benefits from innovative change. However, innovation processes are by definition unpredictable, controversial, and in competition with alternative courses of actions.*

Perhaps the words of T.E. Lawrence (1922), shared by a dear friend and mentor, conveyed the essence of the technology innovation leader who can turn dreams into reality:

> *All men dream: but not equally. Those who dream by night in the dusty recesses of their minds, wake in the day to find that all was vanity, but the dreamers of the day are dangerous men, for they may act their dreams with open eyes, to make it possible.*

What these statements do not convey, is the latent innovation potential that can be released by technology innovation leaders who would like to improve their innovation performance and do not know what to do differently. They can access the technology innovation leader competencies deemed by 266 successful technology innovation leaders to be required for successful technology innovation. In applying these insights through their teams, their success orientations and their ability to turn dreams into reality, the newly-identified leader competencies of technology innovation leaders would manifest in gains for technological progress, business and people.

7.3. CLAIMS

The following research claims were derived from the research findings presented.

7.3.1. Pre-study claims

A knowledge gap was revealed on competencies deemed to be required by technology innovation leaders for successful technology innovation in a “fourth industrial revolution” landscape. Research data confirmed that, despite a recent exponential increase in scholarly publications in the emerging discipline of innovation management, most managers surveyed acknowledged the significance of innovation, and that most of them did not know what to do differently to improve their innovation performance. Research data confirmed that South Africa plans to migrate to a knowledge-based economy in which technology innovation is expected to contribute to national priorities, such as competitiveness and socio-economic development. While performance reviews against these plans showed less than expected innovation performance on key measures, this study assumed that technology innovation leaders would benefit from access to research-based competency descriptions for development and benchmarking purposes.

7.3.2. Claims from the qualitative research phase

As discussed in Chapter 5, triangulated research data from expert interviews, case materials, workshopping and literature confirmed that linear sequential innovation processes may no longer be representative of actual practices of successful technology innovation leaders. Interim capability clusters were identified and were used as research themes to guide the identification of technology innovation leader competencies deemed to be required for successful technology innovation across the technology innovation process, from which constructs and items were identified as variables for inclusion in the quantitative phase of the study.

7.3.3. Claims from the quantitative research phase

The main aim of this study was to identify technology innovation leader competencies that were deemed to be required for successful technology innovation. The interpretative discussions in Chapter 6 can be summarised as follows, to serve as research claims that were derived from sample data and analyses presented, to verify that the main goals of the study had been accomplished:

- Technology innovation processes that were used by successful technology innovation leaders in practice may not comply with conventional linear sequential process models and their core underlying assumptions.

- Technology innovation leader competencies in six capability clusters appear to be adequate for the process models presented and can be applied in different sequences when innovation conditions change and the leader needs to adjust.
- Six technology innovation leader competencies, as well as their underpinning leader behaviours were identified, described and statistically tested, yielding statistically-significant findings, and therefore achieving the main aim of this study.
- The relationships between constructs of the hypothetical model meet the statistical requirements for a reflective PLS-SEM model and can thus be used for theory development. The theory poses that the success orientation of the technology innovation leader influences the integrative leadership of a technology innovation leader, which influences five other leader competencies relating to technology connectedness, stakeholder alignment, liberating mindsets, value creation and value realisation.
- The success orientation (SO) of leaders shows a statistically-significant effect on the integrative leadership competencies of the leader, but this relationship seems weaker than other relationships in the model, which calls for further research and possible refinement of the construct. Technology innovation leaders may benefit from improved clarification of the success expectations for realistic success orientations. Multiple, changing technology innovation strategy and policy directives may leave the technology innovation leader with a sense of confusion and despair when success parameters are not aligned with available capacity. In a developing economy, like South Africa, the technology innovation leader is expected to deliver against technology, business and people targets with sub-optimal availability of skilled people and innovation infrastructure. In practical terms, the research results show that the success orientation of successful technology innovation leaders mostly equates to them trying to perform not only technology innovation for functional improvement and enhanced productivity. They also try to solve problems, earn revenue, contribute to breakthrough technologies for global competitiveness, market creation and customer satisfaction, new ventures for job creation, improved human interface, socio-economic development and human capital development. To improve the relationship between success orientation (SO) and integrative leadership competencies, further research is required to enhance understanding of which combinations of success variables should inform choices made, and in which way.
- No other directly-comparable studies could be found, mainly because of differences in scope, method, analysis and levels of detail disclosed. This study used a mixed-methods approach and analysed its quantitative results using a reflective partial least squares technique in a structural equation modelling method. Furthermore, the use of peer-based snowball sampling across technologies, organisations, disciplines and networks appears to be different from other studies, which could be viewed as a virtue in this exploratory study.

7.3.4. Integrative leadership model for technology innovation

From the preceding discussions and statistics, an integrative leadership model for technology innovation is proposed as illustrated in Figure 7.2.

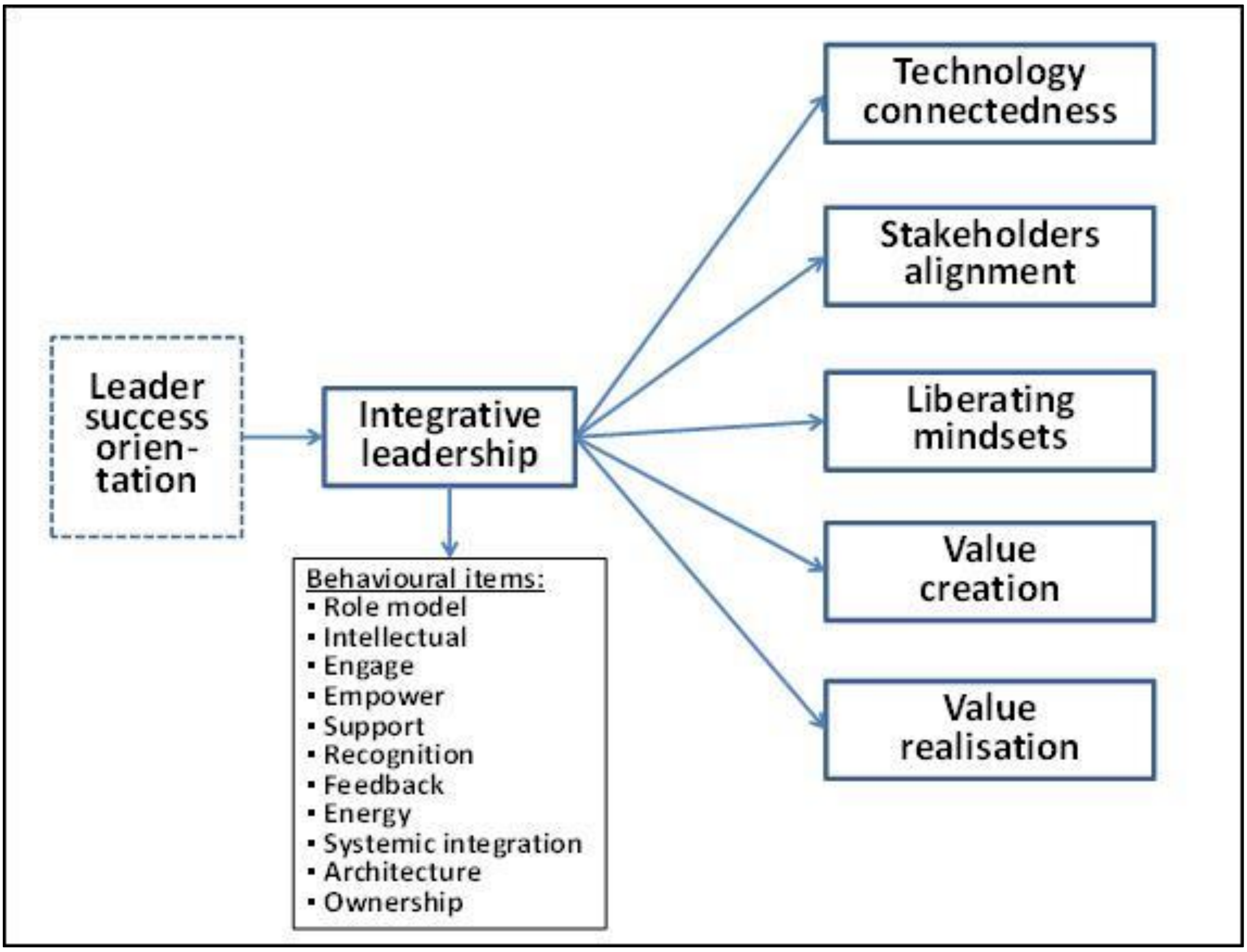


Figure 7.2: Integrative leadership model for technology innovation

As discussed throughout this thesis, technology innovation leaders may benefit from knowledge and mastery of the identified competencies in response to the question regarding which technology innovation leader competencies are deemed to be required for successful technology innovation. The integrative leadership model for technology innovation in Figure 7.2 suggests that the success orientation of the technology innovation leader affects the extent to which the identified competencies are seen as being important for successful technology innovation. The better a technology innovation leader is orientated towards success (which may be determined by other stakeholders), the more integrative leadership will manifest in behaviours aimed at technology connectedness, stakeholder alignment, liberating mindsets, value creation and value realisation.

The leader's association with success relates to ten indicators that were rated above 72.41 percent significance, which suggests that they are all seen as important and being pursued by technology innovation leaders. It may be unrealistic to expect (i) market creation, (ii) technical solutions, (iii) financial yield, (iv) functional improvement, (v) productivity, (vi) new ventures, (vii) human capital development, (viii) improved human interface, (ix) socio-economic benefits and (x) radical innovation from a leader.

Nonetheless, the statistical model suggests that greater success orientation relates to integrative leadership, which is made up of eleven behavioural items shown in Figure 7.2. In summary the integrative leader behaviours of the technology innovation leader include the leader leading by example as an innovation role model, providing intellectual challenges, engaging, empowering, and supporting innovation team members, giving recognition, providing feedback, radiating innovation energy, effecting systemic integration, building an innovation architecture, and instilling team ownership. These integrative leadership behavioural items were rated the highest of all constructs in terms of its significance, and these then relate to the other competency clusters in Figure 7.2 in line with the statistical strengths shown in Figure 6.5 and Figure 6.6.

The weakest relationship in the model is the one between success orientation and integrative leadership, as discussed before. There may be reasons for this relatively low value, other than discretionary association, implied overload or motivation. The results appear to also support the views of Rosenzweig (2007) that leadership is an attribute of success and not the only cause of it.

Further research into the link between success orientation and integrative leadership may bring greater clarity and understanding, and is thus proposed as a next step.

7.3.5. A competency profile for technology innovation leaders

This study aimed to compile a competency profile for technology innovation leaders in knowledge-intensive organisations in South Africa. A literature overview did not reveal any previously-used theoretical framework for use in this study, which necessitated the empirical research undertaken, the results of which are discussed in this chapter.

Acceptance of the statistical model proposed in Chapter 6, served as basis from which a competency profile for technology innovation leaders in knowledge-intensive organisations in South Africa was compiled (Table 7.2 and Figure 7.3), which was the aim of this study.

Table 7.2: Competency profile

Descriptive statistics from Table 6.3	
Variable	**Mean**
Technology connectedness	4.08
Stakeholder alignment	3.62
Liberating mindsets	4.00
Value creation	3.89
Value realisation	3.77
Integrative leadership	4.55

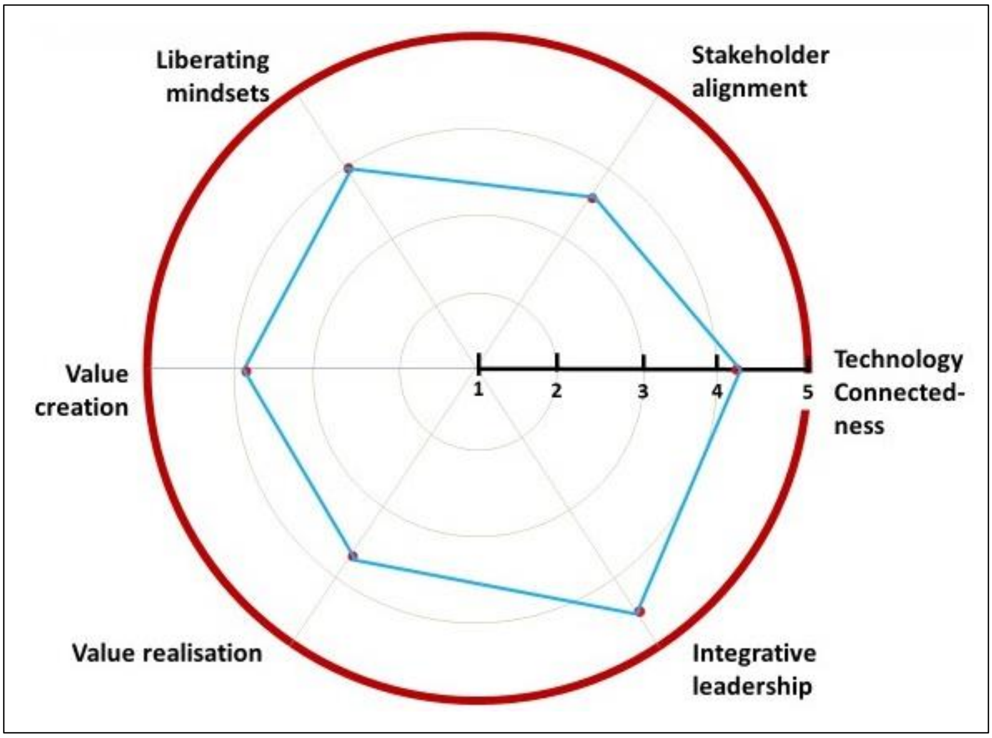


Figure 7.3: A competency profile for technology innovation leaders

The mean values displayed in the competency profile appear to be within close proximity in terms of their significance and their visual representation reflects this observation. While some may challenge the relatively similar significance of the six competencies, others may be relieved that some competencies did not come out as being significantly more or less important than others. Further analysis of the 60 leader behaviours that underpin these competencies confirmed that each of the competencies and leader behaviours was found to be required for successful technology innovation. It is perhaps the notion that they may occur in different sequences, rather than a linear sequential flow, that needs to be emphasised and considered for adoption.

7.4. CONTRIBUTION OF THIS STUDY

The theoretical contribution to be associated with answering the research question, namely the identification of technology innovation leader competencies deemed to be required for successful technology innovation, was portrayed as a set of six competencies with underpinning behaviours in Chapter 5, as a statistical model in Chapter 6 and a summarising competency profile in Chapter 7.

The obtained research results enrich the body of knowledge through their contribution to the areas of theory, knowledge and process as discussed below.

From the results and discussions presented, this study and its findings may be acknowledged for its contributions towards:

- The identification of successful technology innovation leaders through snowball sampling and self-screening, based on stated performance parameters.
- The participation of stakeholders and eligible respondents across a multitude of organisations, disciplines, technologies, value chains and functional domains to include innovation awards winners and technology innovation leaders from areas such as space technologies, ICT, electronic and digital, laser, radar, health, energy, medical, building & construction, materials, environmental, nanotechnology, transportation, automotive, aeronautics, energy management, surveillance, photonics, robotics, chemical, biological, manufacturing, earth observation, mapping, media & publishing, sound & image recognition, modelling and simulation.
- Unsolicited feedback and support received for the non-conventional approach of not merely replicating existing theories from existing academic and work structures, or organisational configurations.

From the theories and theoretical perspectives reviewed, it appeared that further contributions to theory may be required in the following main areas, in order to answer the research question:

- Technical skills and environmental scanning at the onset of the innovation process;
- Integration of multiple stakeholders during the innovation process;
- Non-sequential progression through context-specific stages during the innovation process; and
- Involvement of the consumer in the commercialisation or technology adoption stages.

7.4.1. Theory contribution

The theory contribution entails a competency model depicting relationships between technology innovation leader competencies deemed to be required for successful technology innovation.

Sound theories help to explain important relationships in the world around us and their application facilitates and expedites positive social change. A good theory "explains the world, but great theory transforms it" (Christensen, 2016:1).

Chapter 3 discussed shortcomings in innovation theory and appeals to innovation scholars for the development of new theory to accommodate a cross-disciplinary approach to the role of innovation in society (Fagerberg, 2003) based on "...the creative combination of different disciplines and perspectives" (Tidd & Bessant, 2013:107).

The researcher views the competency profile derived from the research results of this study as instrumental in the emergence of an integrative innovation leadership theory, which is viewed as a contribution to the scholarly body of knowledge in the field of innovation leadership. The integrative capabilities of technology innovation leaders have been mentioned throughout this thesis. The mere acknowledgement of the integrative roles of the technology innovation leader may stimulate other scholars to further explore the theory. In making this claim, the researcher acknowledges related insights emerging from the activities of other scholars.

7.4.2. Knowledge contribution

The knowledge contribution of this study is in the form of technology innovation leader competencies that have been identified and populated with behavioural items that have all been found to be statistically significant for successful technology innovation.

Hypothesised relationships within and between six competencies and their respective underpinning behavioural elements were proposed as a model and statistically validated as technology innovation leader competencies deemed to be required for successful technology innovation.

As a result of this study, technology innovation leaders may be selected or evaluated with reference to the identified and validated competencies and the relationship model and competency profile could serve as a profile for benchmarking and for skills development.

7.4.3. Process contribution

While the use of a mixed-method approach was not new for this type of study, the use of deconstruction to break down and rearrange innovation process elements appears to be new. The result was in the form of statistically-significant indications from successful technology innovation leaders that traditional linear sequential innovation process models can be replaced by technology innovation leaders adopting a context-driven dynamic process with interchangeable capabilities to accommodate changes.

7.5. REFLECTION ON BROADER SIGNIFICANCE AND VALUE OF STUDY RESULTS

This research was aimed at identifying technology innovation leader skills deemed to be required for successful technology innovation in order to contribute to the knowledge base in light of knowledge gaps identified. The rationale for undertaking the study was based on contextual factors at the time. While the results have been scientifically derived, the contextual landscape has been further characterised by an even greater management emphasis on technology innovation. Since the initiation of this study, the following observations have been made by the researcher, which are presented in four categories, i.e. innovation leadership as a concept, and global and local innovation perspectives, as well as leadership development

7.5.1. Innovation leadership

Innovation leadership as a concept has started to appear in scholarly literature (Swart, 2013; Hill *et al.,* 2014). Considering increasing emphasis on technology innovation, the concept of technology innovation leadership as presented in this study may attract more scholarly attention in future.

7.5.2. Global innovation perspectives

This study focused on technology innovation leader competencies according to technology innovation leaders in knowledge-intensive organisations in South Africa. The global research context is still characterised by a knowledge gap pertaining to the leader skills for innovation generally and for technology innovation, in particular. An even more demanding contextual environment is experienced globally, as implied by the following indicators that can be linked to the technology innovation leader competencies proposed in this thesis.

The pace of innovation among global corporations, universities, government agencies and research institutions had surged with a double-digit year-on-year increase in innovation growth across 11 of 12 sectors measured. 'Collabovation' is a term used for the "...elegant convergence of collaboration, innovation, cultivation, cross-pollination and calibration, swirled into the powerful process of bringing inventions to life with strategic partners and suppliers ..." This is becoming a preferred way of conducting innovation in several technology innovation domains with medical devices, home appliances and aerospace leading (Thomson Reuters, 2016: 4).

As the process of technology innovation becomes more collaborative, tools for finding prior research become even more refined, researchers collaborate more with others and pure or basic research investments have been married with innovation, causing the scholarly activity to even out (Thomson Reuters, 2016: 5).

Many senior executives are still challenged to manage innovation sustainably throughout all organisational levels and unlearn old modes of thinking as individuals and as organisations. Thinking differently requires skill and innovation leaders need to understand that innovation is frequently hampered by deep-rooted cultures of fear and subsequent innovation assassination (Brands, cited by London, 2016).

Technology innovation is experiencing exponential growth and the executive chairman and founder of the World Economic Forum, Klaus Schwab, published his views on profound and systemic change which he refers to as *The Fourth Industrial Revolution* (Schwab, 2016:1). A list of 23 technology innovation areas is provided to support his claim that the most intense and important challenge today is "...how to understand and shape the new technology revolution, which entails nothing less than a transformation of humankind" (Schwab, 2016:1). His concern is that "...decision-makers are too often caught in traditional, linear (and non-disruptive) thinking or too absorbed by immediate concerns to think strategically about the forces of disruption..." (Schwab, 2016:2). "Above all, this book aims to emphasize the way in which technology and society co-exist. Technology is not an exogenous force over which we have no control..." (Schwab, 2016:4). He concludes by appealing for multi-stakeholder cooperation across academic, social, political, national and industry boundaries "...to create positive, common, hope-filled narratives..." (Schwab, 2016:4).

This study was conducted with the primary aim of identifying technology innovation leader competencies deemed to be required for successful technology innovation. While other scholars may claim to have made similar contributions, none claim to have reached conclusive insights into this complex and evolving study field and all suggest further studies of the field (Kesting, Ulhoi, Song & Niu, 2015). Other authors have focused on specifc aspects of innovation processes and/or leader competencies in generic innovation areas, but no comparable research findings could be located for direct comparisons. Kesting *et al.* (2015), for example, focused only on leadership as influencing through four generic dimensions of people, means, effects and goals that are not specifically related to technology or innovation processes and the authors made no reference to integration issues that were found to be an important construct in this study.

7.5.3. South African innovation perspectives

South Africa has developed an accomplished track record in successful technology innovations, such as the first heart transplant and the lithium-ion battery being used in cell phones.Thirty South African cases on scientific breakthroughs that resulted in successful technology innovation, were included in a publication initiated by a local business school (Wild, 2015). Another publication paid tribute to South African innovations that had achieved world-wide impact (Grulke & Silber, 2001). Annual South African innovation summits have been held for over a decade and attendees included innovators, entrepreneurs, venture capitalists, incubation centres, science parks, policy makers, and training providers. The summit hosted pitching sessions, hackathons and exhibitions. Professional associations and networks have become active participants in the NSI, such as SARIMA and SAINE.

South Africa's innovation performance, however, have been experiencing a gradual decline in certain areas, such as those reported in Chapter 1 (Insead, WIPO & Cornell University, 2015). More recently some of the global benchmarking reports such as the Global Competitiveness Report released by the World Economic Forum in 2017 shows that South Africa has dropped 14 places on their global rankings and that innovation was rated as South Africa's worst performing pillar of their competitiveness model (Schwab, 2017).

South Africa's innovation challenges are becoming more and more complex, as reflected in national level planning, policy and strategy documents and statements, such as the plans to migrate South Africa towards a knowledge economy, as indicated in Chapter 1. Technology innovation is expected to contribute to national priorities, such as competitiveness and socio-economic development and new demands are being added that have a direct influence on the capacity of technology innovation leaders, leaving some of them with a sense of confusion and despair when success parameters are not aligned with available capacity, as indicated in some of the feedback received (Chapter 5). Table 4.14 shows that the number of researchers per million inhabitants in South Africa was at 382 in 2010, which is low compared to a country like Germany with more than 4000, and South Africa is spending less than one per cent of its GDP on innovation, compared to Germany at near three per cent (Unesco, 2010).

In a developing economy, like South Africa, the technology innovation leader is expected to deliver against technology, business and people related targets, with limited availability of skilled people and innovation infrastructure (DST, 2007). In practical terms, the results of this study show that the success orientation of successful technology innovation leaders mostly equates to them trying to perform not only technology innovation for functional improvement and enhanced productivity (Chapter 6). They also have to solve problems, earn revenue, contribute to breakthrough technologies for global competitiveness, market creation and customer satisfaction, new ventures for job creation, improved human interface, socio-economic development and human capital development (Section 7.3.2). At present, the country has approximately 52 million people of which 30 million live in poverty, including 14 million who depend on a monthly government allowance for survival (StatsSA, 2016).

The South African Management Index Report of 2015/2016 stated that 78.9 percent of SA managers declared innovation as a strategic priority for their organisations (Steyn & Bell, 2016). Between 32 and 52 percent of managers were not sure that they had the right objectives, business plans, skills, processes and environment to achieve innovation success (Steyn & Bell, 2016).

The 2017 World Bank economic update reports for South Africa claims that a lack of innovation is stifling the economy of the country, and that innovation for productivity and inclusiveness should be regarded as a national priority (The World Bank, 2017).

This thesis was about learning from technology innovation leaders who brought about successful technology innovation through teams before, and identifying the leader competencies deemed to be required for successful innovation. Others leaders can benefit from these insights as they engage in the quest for successful technology innovation despite the challenges presented. Leadership development is one such as mechanism through which leaders may be able to acquire the competencies deemed to be required for successful technology innovation, as discussed next.

7.5.4. Leadership development

The researcher has had several requests from technology innovation leaders, consultants and service providers in the leadership development field to make the results of this study available. It appears that current local leadership development programmes exclude leader competencies with technical or functional content.

A PhD candidate at another university holds the view that leadership development of technology innovation leaders requires a make-over and wishes to use these study results as benchmark:

> *…dat ek jou as verwysing wil gebruik in my navorsing waar ek reeds ge-identifiseer het dat [firma] se Technology Leadership Programme slegs fokus op gewone business leadership skills. Ek wil graag onder andere na jou navorsing verwys as 'n voorstel van hoe die program se 'leadeship [sic] skills' moet aangepas word om beter resultate te verkry.* (email received, 2017)
>
> Above Afrikaans quote translated into English: *…that I can use you as reference in my research where I have already identified that the [firm's] Technology Leadership Programme focuses only on regular business leadership skills. I want to…refer to your research as a proposal on how the programme's 'leadeship [sic] skills' have to be adjusted to obtain better results.* (email received, 2017)

Technical and academic qualifications tend to be used in the selection and appointment of managers in technology innovation organisations, but were not included in this study. Unsolicited feedback received from experts, however, suggests that awareness of the findings of this study could expose gaps in current practices to everyone involved in leadership development and result in improved technology innovation leadership practices.

Through interactions with experts and practitioners, it appears that formal leadership development programmes are not being pursued by all employers of technology innovation leaders, but that successful technology innovation leaders tend to be considered for fast-tracking towards executive-level appointments. It would thus be incorrect to assume the existence of formal leadership development through which the study findings could be disseminated.

The researcher is confident, though, that the findings would be favourably considered by decision-makers because of its congruence with findings reported in a recent Harvard Business Review, article claiming that top-performing CEOs tend to survive turbulence through four essential behaviours (Botelho *et al.,* 2017).

These behaviours included: (i) decisiveness towards a desired future despite ambiguity and incomplete information; (ii) engaging employees and stakeholders for impact; (iii) adapting pro-actively; and (iv) delivering reliably (Botelho *et al.,* 2017). Integrity and other qualities may have been important screening factors to filter out unsuitable candidates, but "they will not help you separate the best from the rest. Consider that 100% of low-performing CEOs in our sample scored high on integrity, and 97% scored high on work ethic" (Botelho *et al.,* 2017: 70). Their success is thus related to their behaviours.

Implementation of the findings from this study acknowledges the longer-term perspectives required for behavioural change to take place. A phased approach is envisaged for the implementation of the findings. The first phase will focus on raising awareness through scholarly platforms such as SARIMA events, publications and publicity. A summary of the findings will be emailed to survey respondents who indicated further interest in the study, together with contact details and follow-up mechanisms to enter into exploratory conversations aimed at identifying early application projects or groups. The measurement instrument will assist in doing gap analyses and prioritisation of development needs. Priority needs would inform timing and resourcing decisions for the development and facilitation of individual and collective learning programmes, after which post-learning assessment will take place.

The actual implementation of the findings, therefore, is envisaged to take place as collaborative programmes involving the researcher, line practitioners, and functional services staff with the focus on selection, training and development and performance management. The researcher would oversee the interpretation, adoption and application of the measurement instrument and facilitate and support the design and implementation of suitable development frameworks based on adult learning principles. Functional services staff would include those involved in the selection and development of technology innovation leaders, such as human resources professionals or learning and development managers. Line practitioners include current and aspiring technology innovation leaders working in NSI-institutions, such as universities, science councils, research laboratories and collaborative innovation programmes.

Further scaling of learning content based on the study findings may be considered through train-the-trainer schemes, certification and continued professional development, and the results from learning and development programmes analysed to inform further research in this domain.

7.6. AGENDA FOR FUTURE RESEARCH

As discussed in Chapter 1, technology innovation leaders experience similar challenges globally, which suggests possible the replication of this study internationally, as this study focused on technology innovation leaders at knowledge-intensive organisations in South Africa.

It seems clear, at least at a broad level, that technology innovation leader competencies that are deemed to be required for successful technology innovation have been identified. This observation, however, should not be taken to imply that these findings represent the definitive work on leader competencies for technology innovation. Instead, this study provided groundwork for subsequent research.

Further research is needed into the weaker than anticipated relationship between success orientation of the technology innovation leader and the integrative leader competencies of the leader. New insights may inform decisions for optimal goal setting and ownership.

Repetition of this study to observe any changes in findings over time may reveal patterns related to leader competencies and the nature of the dynamic process in different technology domains that may influence decisions related to leader development pathways.

While the repetition of this study with a larger sample may include technology innovation leaders who were unable to participate in this study, other methodological issues can be explored, such as the prevalence of self-reported data and the nature of the measurement instrument.

Extension of this study to include perspectives gained from stakeholders would allow for comparative analyses and the exploration of possible similarities and differences between the perspectives of stakeholders, which may be related to technology innovation leader competencies.

This study may also be conducted in future with more emphasis on the actual technology innovation successes achieved over time to serve as research inputs for the possible refinement of the measurement instrument.

Further research is needed into the thinking processes of technology innovation leaders, including how they make integrative decisions leading to integrative behaviours.

While the success orientation of technology innovation leaders was included as a model construct, it may require further development. While such comments were not recorded at the time, several respondents had contacted the researcher during and after the study to express their sense of frustration in attempting to understand and deliver technology innovation solutions when funders and power figures keep changing the success parameters and administrative compliance requirements, while expecting technology innovation leaders to adapt to changing priorities and fluctuating resourcing. To improve the relationship between success orientation (SO) and integrative leadership competencies, further research will be considered to enhance understanding of the specific combinations of variables that inform the choices made, and in which way.

7.7. CONCLUSION AND SYNTHESIS

Mankind is entering a period of unparalleled scientific and technological advancement in which technology innovation brings new challenges and opportunities to management (Schwab, 2016). The task ahead for leaders is unprecedented and will require the ability to navigate complexity, and translate risk into opportunity (Schulschenk, cited in Veldsman & Johnson, 2016:320) and in Africa growing emphasis on leadership will be important (Vilakati, cited in Veldsman & Johnson, 2016).

The main research objective throughout this study was to identify the technology innovation leader competencies deemed to be required for successful technology innovatioin. This study identified technology innovation leader competencies deemed to be required for successful technology innovation in order to address an identified knowledge gap in the body of knowledge. These leader competencies and their underpinning behaviours have been identified and their significance tested from which an integrative leadership model for technology innovation has shown statistically-significant relationships.

The study also addressed the research sub-questions identified in Section 4.2 which resulted in the linking of relationships between competencies in a statistically sound model of integrative innovation leadership, and the creation of a conceptual competency profile linked to a measurement instrument to achieve the aim of the study as reflected in the title of this study.

From a practitioner's perspective, the research findings provide leader competency descriptions and a model for benchmarking and developmental purposes. Leaders who want to improve their innovation performance and are willing to explore behaviours beyond their current skills sets may benefit from acquiring these competency sets in pursuit of better innovation results. While technology innovation leaders may be appointed for their technical proficiency, they need to understand that their success orientation influences their integrative leader skills, which in turn directly influences their dynamic leadership of technology innovation competencies.

From an academic perspective, limited research appears to have been done beyond discipline and theoretical boundaries. This research has developed a comprehensive theory-based success-orientated leader competencies model derived from the experiences of successful practitioners. This research proposes leader behaviours across a dynamic innovation process and challenges innovation leader practices that assume a linear sequential predetermined innovation process. While innovation process models tend to start with idea generation, this research shows the significance of being connected to evolving science and technology breakthroughs as well as evolving stakeholder interests in liberating mindsets, while focusing on value creation and realisation. Integrative leader competencies appear to be vital for success. The integrative leadership for technology innovation model, illustrated in Figure 7.2 provides a holistic and integrative perspective on leader competencies for successful technology innovation and can be applied by those involved with technology innovation. What started as a complex range of leader behaviours linked to specific phases in a linear sequential pre-determined approach to technology innovation has been simplified into a simple dynamic model.

A summary of the salient implications of this study include:

- Greater clarity on success indicators for technology innovation will have a positive influence on the integrative leadership practices of technology innovation leaders.
- Stronger integrative leadership relates to stronger leadership in technology connectedness, stakeholder alignment, liberating mindsets, value creation and value realisation.

- Technology innovation policies and strategies may be updated to reflect the reported insights and include leader development that extends beyond technical competencies to include the non-technical leader competencies identified.
- Non-linear processes may be used to accomplish technology innovation. Traditional innovation practices may have to be reviewed in light of the findings, where innovation management still assumes a linear approach to innovation, in which science leads to technology, which, in turn, is expected to satisfy market needs.

It is thus concluded that, access to the contributions from this study to the knowledge base, not only benefit technology innovation leaders, but also the other stakeholders as identified and discussed in Section 1.6.

From a synthesising perspective, the following observations are considered as important to link the parts of the study into a connected whole, using the components of 'doctorateness' intoduced in Chapter 1 as the connecting framework.

- The stated gap in knowledge or practice concerned a perceived lack of uncertainty experienced by technology innovation leaders about the competencies deemed to be required for successful technology innovation. This was particularly important in a South African context as a developing country with limited resources and increasing demand for innovative solutions to problems and challenges of a competitiveness and socio-economic nature. This study provided insights that can alleviate uncertainty and direct the developmental efforts of leaders.
- The explicit main question for this study was: "What are the leader competencies that are deemed to be required for successful technology innovation?" Research sub-questions were added to direct the research, resulting in insight regarding technology innovation processes and technology innovation leader competencies for success.
- The provisional conceptual model for this study presented in Chapter 1 featured as an integrative reference base throughout the study. From the beginning to the end of the study the focus was on the technology innovation process and the leader competencies required by the leaders of technology innovation to lead teams from insights and ideas about problems, challenges and opportunities to technology solutions. The conceptual model determined the structure of the literature review. The corresponding interim clusters of capabilities identified at the beginning stages of the study were adjusted and refined to become research themes and then competencies as sets of leader behaviours associated with successful technology innovation.
- The sequential exploratory design as a research design legitimised the exploratory nature of this study by first accommodating a qualitative interpretivist research phase to generate data from which to develop a measurement instrument for use during the qualitative positivistic research phase.

- The appropriate methodology in this study comprised the use of appropriate research techniques for obtaining research data, while anchoring the research in a pragmatic paradigm.
- Data collection consisted of qualitative research sources (experts, cases, workshops and literature) and quantitative research data obtained through a measurement instrument used in a survey with respondents being identified through peer-referenced snowball sampling.
- Research data was analysed to provide both qualitative findings on the identification of technology innovation leader competencies deemed to be required for successful technology innovation, and quantitative results for testing the significance of leaders' competencies in achieving successful technology inoovation.
- Theory development emerged as an integrative innovation leadership model that showed statistically-significant relationships in the model.
- The full engagement with theory in this study manifested in an integrative leadership model in Chapter 7.
- Cogent argument throughout was guided by the conceptual model.
- Research questions were answered (Sections 3.1, 4.2).
- Conceptual conclusions were drawn (Section 7.7).
- The contribution to knowledge from this study includes the identification and description of leader capabilities deemed to be required for successful technology innovation, their underpinning behaviours and a competency model presented in Chapter 7.

7.8. PERSONAL REFLECTIONS ON THE RESEARCH

While this thesis concretises the work done to crystalise and answer the research questions by using the tools of science, it remains part of a larger journey and growing sense of awareness that the creation and application of new knowledge coincide with new insights and possibilities.

It is my wish that those who supported this thesis may benefit from its release and that those in positions that can help to make technology innovation leaders more successful, be inspired to use and further contribute to these pages.

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APPENDIX A:

EXPERT OPINIONS ON TECHNOLOGY INNOVATION PROCESSES

The listed entries below were extracted from transcribed versions of personal interviews conducted with experts in the technology innovation leader domain. Their views were expressed in response to the research question relating to their views of the technology innovation processes used by technology innovation leaders for successful technology innovation. The codes at the start of each statement are used to protect the identity of interviewees in accordance with the undertaking conveyed in the ethics section of the letter requesting the interview. The entries appear in no particular or pre-determined sequence and will inform the formulation of questions for inclusion in the measurement instrument for testing of assumptions during the validation and pilot study phases of the research.

EIEohML: ...There has definitely been a shift, from an industrial to a knowledge utilisation paradigm. Let me take you through our journey. We started in 1948.

EITelkBF: It sometimes becomes very painful because some companies are very process driven and I think sometimes innovation is actually stopped by a very process driven company. You can't be fast and reactive as far as that is concerned

EICsirJlR: The innovation process in my view would be, and I've identified this in working with leaders driving technological innovation from a technology point of view as well as a business point of view... I saw with many of these that the formal linear process is just there to ensure that guidance and order is there to direct your thinking and planning and execution. It is not necessarily linear and sequential

EICsirJlR: The technology innovation leader has to come back and review overall progress not just in one box at a time but several blocks to ensure progress. I think it's important to do that on a regular basis to make sure that you are on track and that you are addressing the right issues.

EICsirJlR: You learn from the various involvements in the various phases of the process and that informs the decisions on the way forward. This contributes to the main innovation phase where you are. So in my view no point I think is great to have that as a model the kind of standard approach which is important for overall guidance and direction and to check where you are but not necessarily to follow it step-by-step phase by phase

EITelkSL: So, I think there was a linear process component in the lab once, they had a certain amount of rigour but I think in terms of setting it up for innovation it was not linear, it was more about setting the people in the system up to be successful which is a bit different.

EIDaVRM: What we are seeing now is a much less formal process. Let me give you an example. In technology top 100 we are picking up companies, as I was telling people last night, like this one company who turns around and says on Friday morning there is no work formally in the organisation. You either sit with your colleagues and you talk to them about ideas or in fact you sit on your own but we expect you by lunchtime

EIDaVRM: We are very sceptical about some of these processes. Look, you cannot deny that some of these stage-gate processes are important and therefore when you talk about the process I still think that you have to have stage gates where you sit down and you talk through the stages

EIDaVRM: ...When these companies go through stage gate they say look, here is (innovator), he has a brilliant idea to develop a model for technology leadership and he has almost set himself a roadmap and on the strength of finishing phase 1 where he has gathered all the data and when you review this thing you say it is not panning out the way I wanted it to and then what they say is what are the other options that might come out of this thing. In other words they would go and provide a formal process of achieving some end goal and then say hey you know what, we've had this interesting breakthrough in events which we never anticipated.

EICsirJIR: He said it so bright that you don't need a light. So David King said to his wife I think this guy is drunk. Anyway he said I'll meet you at 9:30 tonight because it gets dark quite late in summer and sure enough they walked inside the laboratory and in this was glowing. The intention never was to develop such a chemical but out of that developed this multi-million Rand emergency lighting system which is just a chemical.

EIDaVRM: What you are seeing is acknowledgement that technology innovation exposes the company to huge amounts of risk, you can't deny you can't also have it at the same time as a linear process. It is in fact very non-linear. So we are saying that the process is more around engaging people, more around creating an environment which is really conducive to alternative thinking and very conducive towards listening and exploring and things like that, you see this becoming more and more, like contagious.

EIDaVRM: One of the executives who recently retired from Altron said "you know we're good but we could be so much better if in fact we were to look at the more relaxed approach to leading innovation".

EIDaVRM: So, I think when you look at the process there is a lot of informality...They got this guy on board who became one of the leaders in the field... But he can talk to anybody at any level, and talk to you, the head of a company. To him he is not worried about this process thing and he talks to people at all levels.

EIDaVRM: I think also that in these competencies is this issue around the market push and market pull. When you look at Sony, who in its heyday was definitely working on market push. Sony never did any market survey. They would rather say we have a hell of a good idea, and turn around and say how do we actually persuade...

EICokGW: What was needed by the company at the beginning of the journey and still is needed is some nomenclature and processes that support the acceleration of innovation, the understanding of it and the activation of it by organisation.

EICokGW: When I have for instance the big town hall meeting with the technical community I would always say stay eternally curious. Stay curious. We all have a job to do, we have performance objectives to meet but on top of this stay curious whether it's related to your job or not even related to your job... If you are curious then you connect, and if you connect you can collaborate, and the more you collaborate the more you will collect the benefit.

EISasTD: I don't think the processes themselves will result in such innovation, but it creates an enabling environment in which the innovation can take place.

EISasTD: People tend to say you need anthropy 4:29 to achieve innovation, which has some merit. Then you come to environments like (confidential) where you have a strategy that is very crisp rather than pervasive, and then you need to respond to, and you then need to have an innovation process that ensures that everything you do contributes towards the strategy. So there is a lot of formality and there is a lot of structure. One needs to be careful about how you talk on innovation in these two environments.

EISasTD: Having the process should at least allow to plan for what you want to achieve, because it is by following the plan you are able to take the ideas all the way to the point where you can make an informed decision, whether you continue with it or you stop it or you commercialise. You can hide behind a lack of structure which then becomes an excuse for not planning properly and being held accountable for achieving the planned results...But the structure and process need to be nuances for the specific environment. And I think they are differences between the academic environment, the environment of the science councils and the environment of the private sector. You may not be able to same approach but nonetheless need a process to apply. Another very important process for me is to have an integrative innovation model.

APPENDIX B:

TECHNOLOGY INNOVATION LEADER BEHAVIOURS DERIVED FROM EXPERT INTERVIEWS

#	**Capability cluster 1: Being connected with the evolving technology innovation landscape (TC)**	**Code**
1	EIEohML TC: Today we have systems with millions of lines of coded immediate access and used in a range of applications, like rental calculations to ensure accurate billing. I can only imagine what chaos must have existed when everything was done by hand.	A2
2	EIEohML TC: We started migrating from (confidential) systems to time and attendance machines. The international relationships and local market changes during apartheid created the environment. The political situation made it increasingly difficult for us to import and we had to become self-reliant and produce our own technologies from whatever technology components were available.	C1
3	EITelkSL TC: So he had a problem where the lead robot had to communicate with the others. The communication would only work when the motors were off so one circuit would link with another circuit. So it turned out that the solution was partially still that idea where he was able to control all these microprocessors, the communication only takes 25 Milliseconds and switches off the motor from the transmitting robot for 25 Milliseconds	C6
4	EIDaVRM TC: If we look at the technology innovation leader competences we are beginning to see competencies that are absolutely key to successful innovation. Number one is a highly highly developed sense of what the technology is all about. What we are saying is that you do not have to be the expert in the Knitty gritty of it but you have to be able to understand or be able to generate enough information around with the potential impact for this technology might be and could be. I think that that kind of sense of assessment of the technology is pretty important	A6
5	EIDaVRM TC: Make sure that you've got your antenna out, to pick up on competitor intelligence, I mean they run in a war which means they literally got to be able to say I am willing to listen to anybody, you cut down on hierarchy in the organisation and you become very sensitive what's going on.	A3
6	EICsirJlR TC: if we talk about technology innovation as in a platform or a product, then things like having a good understanding of the technology, and understanding of the field is most probably quite important. If it is more innovation in the context of concepts and models and strategy, then was probably the lesser extent	A5
7	EICsirJlR TC: innovation either by the individual himself but also by the team, it's important to have a good technical understanding and knowledge of that field where as I say it is more process related innovation is most probably the opposite. Then I... Again, my view would be someone that has the good balance between technical and business strategy that balance is important to see things through. It goes together with operational discipline, meaning making sure that things tick over, rather than falling in love with a particular product or process that you have adopted.	F10
8	EICokGW TC: you do a lot of research and talk to a lot of people and when I did that I attended a lot of events and spoke to some of the leading experts and universities in the world.	A1
9	EICokGW TC This is really very very difficult to do. It requires a different mindset so here, and one other thing is another room that is under my range of responsibilities, is this reaching out for new technologies. And here I will provide three different lenses. From a technology point of view, irrespective if it is in the digital world or the non-digital, more physical world. We do this in three ways, we call this first one inside in, inside out plus outside in. Let me explain.	C6
10	EICokGW TC could be an idea or whatever mix of your own skills and specialities you have available in your eco-system which includes your network of agencies and suppliers	C4

11	EICokGW TC means you know what you want but you know you don't have the technology solutions within your own eco-system. Now you go and scout externally and then you bring it in. For that we have set up a network of 12 hubs around the world with major universities, research centres, academic institutions and also research companies and government. We either have a presence with them or we have an agent there or we have a very good relationship with them. So, we do our scouting through these hubs of innovation in the hotspots of technology invention so we are very close to new things coming up.	A2
12	EICokGW TC then we have outside in which is where we do not even know what we want but I do know that we need to be out there. Example is where we have a close relationship with Singleton university in California. I don't know if you are aware of them... They do crazy things in terms of thinking, the network of people that they have. They are really in my opinion at the very forefront of thinking and of technology and research or at least networked with people who are at the edge of new technology research in every type of industry. So that's an example we say we just need to be out of there.	A3
13	EICokGW TC Let's see what we find and connect with it, then we look at it inside. It may be coming from industries that historically have had nothing to do with but it can open up new ideas and open new doors.	C3
14	EIEohML TC: I was at an international conference in Turkey last week to pick up on the latest thinking and my observation is that we are unique in the world in the way that we combine leasing arrangements with technology customisation for the market.	A10
15	EIEohML TC: innovation today is much more on integration of available technologies and very importantly what the customers want on the computer screen and the reporting requirements	C6
16	EIEohML TC: So, there's innovation on our own systems but with new technologies added.	A10
17	EIEohGL TC: we used to in the good old days have massive companies like GE with the labs and scientists, we kind of had all knowledge and information contained in a physical space that is now freely available to everyone. The guy in the bedroom or garage is equally empowered as those scientists were before	A2
18	EIEohGL TC: The idea is probably going to evolve so let me put the right people together to make it happen but it's about understanding that technology by itself does not sell and I'm saying this from my marketing background, the market is going to determine if an idea as commercial value or not	D2
19	EISasTD TC: there is an oversupply of knowledge and the emphasis shifted to what is done with the knowledge	C5
20	EITelkBF TC: I come to work every morning and get my updates on a daily basis, I get about three different letters giving me basic perspectives on what is happening. I can see if there is anything that I need to get more details on, I mean I don't have the time to do that as I did when I was in the specialist field before. When I was in specialist field I could arrive in the morning and go through much more than I do now; now I literally scan because you get given so many other shit to do, that's why I say these people must be taken out of that mindset.	A9
	Capability cluster 2: Mobilising stakeholder alignment, support and participation (SH)	
21	EIEohML SH: So, we do R&D but the main focus is to pick up new information that will affect our future sustainability and develop pathways towards customer value. And our customers trust us to do this. They come to us for help with new problems and requirements and invite us to become part of the solution.	A4
22	EIEohML SH: Finger printing will be with us for a long time but veins are sitting at the entry level so we have to determine the right point of switch over for those involved to derive maximum benefit for all. I must make sure that I speak to the right people in the stakeholder and customer environment to determine this.	B1
23	EIEohML SH: The control was, is no longer just between the user and auditor but much wider to integrate several other users and beneficiaries in terms of their requirements	C6

24	EITelkSL SH: First of all, you've got to start with it before the opportunity is identified. I think to innovate you've got to have group of people that are good.	B6
25	EITelkSL SH These were people that could do stuff which obviously could do things better than he could himself and that were challenging. It was not about mediocrity, it was about something much better, it was about people who wanted to exceed.	B6
26	EITelkSL SH: stakeholder alignment which in my experiences has been the hardest challenges ...I mean it is emotionally draining, but you've got to realise that you need that stakeholder support.	B3
27	EITelkSL SH It is working because it's been supported by the organisation	B3
28	EITelkSL SH Normally the company doesn't like interference but this is one that they've accepted and allowed to work	B5
29	EITelkSL SH we established processes right across the organisation so that you are not in silos to actually make it better for the customer outside. So, to get that to work, to get the process to work across the organisation is very very difficult	D9
30	EITelkSL SH In order to do that you've got to manage the stakeholders, you've got to hold people accountable and they don't like that [governance]	B5
31	EISasTD: (We have) very strict governance which is very tight in terms of the questions you ask, how you provide answers and how you evaluate. Whether it is the review committees, how they meet and how decisions are made on the way forward. This includes how you constitute, how often you meet to ensure that you are going to meet your objectives	B5
32	EISasTD: There are various processes in my view that you need to have in the innovation environment. The first one is governance and the governance process. And the degree of how tight that governance processes is, may differ between Sasol, the science council and university environments.	B5
33	EISasTD: So it's the stakeholders from customers' perspective, in other words the people that we do the work for and all related perspectives. So, we talk about resources, direction, and then the other critical part is you have to ensure that the direction or past that we take talks to the broader organisational direction and priorities.	B4
34	EITelkSL SH stakeholder alignment and mobilising its quite important	B8
35	EITelkSL SH You can come up with a perfect model if some stakeholder thinks it is wrong, you may not succeed.	B3
36	EITelkSL SH. I think that is certainly the big challenge we have got for our technology innovation leaders.	B2
37	EITelkSL SH if you do not have the stakeholder alignment it won't happen	B2
38	EITelkSL SH I prefer to work with a team of people who know what has to be done and they deliver it and its quite straightforward and people know you are in charge of it and you own it.	B9
39	EITelkSL SH So the challenge is that because I'm working across silos and I'm working with people to stimulate them to collaborate you know that when people say: "This is my area and I don't want you interfering"... This means you've got to change... You've got to get people to work together and I'm actually struggling with this	D9
40	EITelkSL SH Moving things around, moving the dial is quite hard. I don't know if I am a real innovator but somehow, I am expected to be an innovator by being the leader, causing other people to innovate and to fix things	C3
41	EITelkSL SH Within a big organisation like ourselves you have to deal with politics and I think that can be why people struggle to innovate	B1
42	EITelkSL SH Trust is really important.	B1
43	EIDaVRM SH: And I think that is something where it is also critical that marketing comes in. How do you actually understand the real commercial value and opportunities for innovation?	A6

44	EIDaVRM SH: So as a competency it is important to understand the drivers of the market, and then the able to adapt	A5
45	EIDaVRM SH: Many top executives are meglo-maniacs who want to control everything. What you are seeing is that successful technology innovation leaders who come out saying I need to partner with the best and we are seeing now more integrated supply chain innovation. The supplier and you as the end product developer work together to provide and we are seeing this as very very important in managing the value chain	B5
46	EIEohML SH: A big trend now is a move away from the office environment towards a home environment which calls for a different approach to how technologies and technology configurations are done. The customer is increasingly becoming his own architect,	B4
47	EIEohML SH: There is absolute trust. I would typically get three proof of concept proposals, select one and only pay when the job is fully done to my satisfaction. If I had to ask my own people to develop a proof of concept, it will cost me in the region of half a million rands.	B1
48	EIDaVRM SH: While Business schools say you've got to focus focus focus, Brian Joffe is not focused yet everybody would hold him up as highly successful. He is not focused, he is into everything that moves. So, these are the challenges that technology innovation leaders are facing.	A7
49	EIDaVRM SH: Also, how do you go to the board who is risk averse and persuade them to start following a different approach? I think that also is a critical thing.	B3
50	EICsirJIR SH: Next I think the whole thing of collaboration networking communication, that capability, in my opinion is good if it sits in the leader who can strengthen it obviously with the team.	F10
51	EICokGW SH: So that helps you to look into those directions for innovation, we innovate for bringing more refreshment which could be product innovation package innovation and equipment as we say which could be cooling machines will bring refreshment to people in new ways.	C3
52	EICokGW SH: that is very interesting how this has brought people together. R&D, our consumer affairs people, public relations, different groups of marketing even. The program has brought them together. We now have innovation leadership communities over here where we touch base on a regular basis and refine our thinking and gradually we will apply certain processes where we can agree, yes let's do this together	F10
53	EICokGW SH: You cannot individually try to design a new operating model or operating system that works for everybody. To capitalise on the trends in personalised consumerism you need to do this in a holistic way in a 360° set of factors.	F10
54	EICokGW SH: So if I call a meeting and the Chief Marketing Officer, the head of R&D and the heads of PR and marketing ventures all show up, it means that they all want to be part of this. It would have been much easier to say that I'm busy, that my schedule is full or other excuses.	B1
55	EIEohML SH: I believe most of what we have today came about as a result of the political dispensation. If you look at what happened in the days of (confidential), we had people bringing in computer parts as part of the luggage when returning from overseas trips. We re-engineered these components for use in locally designed applications. This is what some of our colleagues remember from our earlier days. That was the basis from which our company involved.	A9
56	EIEohML SH: We deal with government we deal with mines and running dual supply chains through essentially the same organisation became too cumbersome and expensive.	F10
57	EIEohGL SH: You must be competent in dealing with a whole diverse range of people. These people could be your own or external to the business. You must be able to understand diversity in people's diverse expectations, you have to be able to articulate his expectations and allow them to guide you as the leader in your behaviour. On the Internet this could be somebody that you have never met, yet you will have to be able to connect and establish a good relationship if you want to succeed. You are dependent, so you have to be competent enough to communicate clearly and to articulate your requirements as clearly as possible to avoid incorrect interpretations of both ways.	E3

58	EIEohML SH: The MD of that group, has been with us for 23 years. So, he understands that technology, and he understands the market and understands the client	B1
	Capability cluster 3: Liberating mindsets (LM)	
59	EITelkSL LM you have to create the mindset that things are going to change	C1
60	EICsir RC LM: I believe that mindset is the critical matter, to see behind a rock while others see the rock. It's like you don't see this rock in front of you to distract you from the goal which is behind the rock so you find your way around it. Some do this with much exuberance and energy...	F8
61	EIEohGL LM: Anyone can come up with an idea, and it could be the DNA of a person to say for instance in my job I'm doing the following things and I think it can be done better	C3
62	EIEohGL LM: Like someone saying I thought about or I see my customers are asking for certain things and I don't see such a thing in the market, it may be a good idea to explore and we should consider investing.	B2
63	EIEohML LM: we could not bUy these machines from abroad, doing it on paper would be too cumbersome and expensive, so we had to apply our minds to come up with local technologies that will help our clients to meet their objectives	C1
64	EIEohML LM: So we spend a lot of time overseas to know what's happening in the technology space and we spend a lot of time with stakeholders in symposiums and others forums. Over time we have developed smart people that are capable of scouting the environment to provide us with the right information for decision-making to inform our future innovations. This allows us to focus on a portfolio of R&D initiatives	B9
65	EISasTD LM: a system that helps you to analyse your portfolio. Because that's what you really do, you create a portfolio of options, some will succeed, some will fail	A7
66	EISasTD LM: When you apply the principle of portfolios, then you can make choices and make sure that you provide support for taking important innovation focus areas forward. This allows you to close the gaps	A7
67	EIEohML LM: About 50% of our innovation is triggered by new technology, particularly where the functionality of previous technology had been increased and improved through more powerful technology. The other 50% comes from customers who have moved from time and attendance systems to payroll systems to health and safety systems and will continue to change.	A10
68	EIEohML LM: There's a number of critically important competences. Number one is to be open to new input all the time. Your head must be very open. Something you said no to yesterday may be an attractive yes today because of changes. (=Agility)	F1
69	EITelkSL LM: Now I think innovation is going to come out of that. I was at this session today where they've been trained for two days and there was a bunch of people, about 10 technicians and the artisans going out there and they then have to discuss, led by the leader, why a particular experience was good or bad.	F4
70	EITelkSL LM You can see innovation starting because of the questions they ask and the perspectives that they are sharing that results in better understanding of the needs and sensitivities of the customer	D3
71	EITelkSL LM we noticed is that as soon as you start putting values into the NPS it starts off as a negative, something like -40 it goes in a matter of weeks quite quickly to positive +10, the point is that innovation is taking place because they are now saying how can we improve the way we do things.	D5
72	EITelkSL LM: You have created the space for them to develop new insights which got them motivated and keen to bring about improvement	D3
73	EITelkSL LM: So, for me this is innovation within an environment for that to happen.	C2

74	EITelkSL LM LM/IL: the point is I think anybody can be innovative but the system has to be there, the environment has to be there and I think you need to take a group of people and give them room to innovate and the opportunity and the environment has to be good. I think the scrum that is happening is an opportunity for ideas to flow across the lab and I think we have set up some good equipment for them to use.	C2
75	EITelkSL LM: it is very important for people to be open. So, I think it's important not only for the leader to listen but also for the people involved to listen	C2
76	EITelkSL LM: One of the things that I personally battle with as an engineer who has worked in marketing it has helped me to understand the customer a lot better, is to work with the psychology of it.	B2
77	EIDaVRM LM: the important thing was that that node came from a young 26-year old employee who had been working for the company for six months. But they were willing to listen, they were willing to put their money where their mouth was. It has taken a number of years to develop. But the point was that this idea came from a completely informal process. Nobody at Altech or UEC had ever thought of the node. The point is that they realised they had a problem with this strategy and were willing to go down bleakly non-linear process to explore a different business model.	F1
78	EICokGW LM: So, if people invent a new way of doing things in a company that delivers value by saving time it is also innovation. Now people realise that everyone can innovate.	D1
79	EICokGW LM: human nature is to do your own thing, be quiet about it until you can demonstrate how much you are heroes and then you find that there are duplications all over the organisation. So, this is why I do this, why I try to get people to see for themselves the benefits of at least embracing the basic principles through which we can contact and connect more	F10
80	EICokGW LM: When you say liberating mindsets I would make sure you include empowering people, tell them you have it in your own hands	F4
81	EIEohML LM: You absolutely have to understand the financial models underpinning your technology architecture. You cannot put these technology solutions on a piece of paper and convince anybody that they will work. You have to incur costs to develop technology demonstrator versions of your concept. You have to be able to convert technology thinking to financial implications like being able to say the best I can earn would be half a million rands, so my solution cannot be attractive unless I spend significantly less on its development. This is get feel based on the intuition and understanding of the innovation environment	D4
82	EIEohGL LM: Me it's a case of a very agile approach. I think there is something let me test it, let me test the concept, let me test the thought, let me get that feedback and then let me build something lightweight so that I can get more feedback, so that I can get more feedback and see how it evolves. So, it's about trying something, fail fast and not to assume that you know what the end product is going to look like, but have a general idea of which direction you are heading and why you think there is a value proposition. ..	C9
83	EIEohGL LM: The process in our world will be driven by passion. If you get somebody coming in who says I honestly believe that. You know I've been involved in this industry that space for this period of time and I think I have seen a gap and this will address it. So, I need some help to make this a reality. So, we help him to test assumptions and if it still says uhm there may be something that is potentially of value or of demand. Then to empower this person that has that passion, to come up with the tools to make this a reality.	C1
	Capability cluster 4: Facilitation of value creation (VC)	
84	EITelkBF VC: The leader has to ensure connectedness with the evolving technology innovation landscape and the stakeholder community. If I go to retail and ask them what their clients want they probably cannot tell me. So, people hire consultants to do this, they don't know how to get to that level of understanding to their own job. Ha ha. That explains why it is hard for them to deliver value to the client	E4
85	EITelkBF LM: that people work for people and people who share a similar thought pattern can actually innovate together and they can do this much faster. I would say there is much less disruption and questioning	C1

86	EITelkBF VR: But sometimes to take those concepts and take them to the next level and do it fast that sometimes maybe calls for a different type of innovation like getting it to market. Sometimes it is about getting things in the market to be more useful or less problematic. You know there sometimes are long development cycles to go through, meet standards and everything	E10
87	EITelkBF TC LM: I don't claim myself to be an expert in management but I do my best. From a technology point of view, I can go away and study, I can apply myself and be innovative or creative and look at things or do what is sometimes referred to as having a crystal ball in a certain field and to say yes this is for us or no this is not for us. You sometimes need like-minded individuals to be able to work with	B6
88	EITelkBF Process: I tend to do step number one, step number two and step number three and then step number six and then step number 10. All the steps in between are irrelevant to me because I think people see them. To me this seems a logical as far as that goes but it's not logical for them.	C9
89	EITelkBF IL: And the guys actually understand that and that's why I need to have people that... I accept that for 10% or 20% you've got to accept the shit and deal with it, as far as that goes. But 80% of the time but more freedom for myself and I'm sure that differs from individual to individual.	F4
90	EITelkBF IL: they must be allowed a certain freedom. You must not tie them down to a specific...uhm... Like micro manage them. It is most probably you've got to get to the stage where the guy says: You now have to stop messing around and tell me where you are... I draw a line between two different things and I say if that guy's got the skill to be able to do it then you give him the concept but if he hasn't got the skill and the capability to do it, that ability to... Well first of all is it in his best interest because if he doesn't want to do there is absolutely no point in giving him this	F4
91	EITelkBF VC: he enjoys it because it takes different pieces of software, looks at how they interact, total range of things outside the standards of the company but not to jump off the building...he gets to a stage, and you've got to decide where this point is, to say listen, on Monday you're presenting, like going team in a Friday afternoon saying the k*k stops now so give me what you got and I need it by Monday. Because otherwise the guy will just carry on in this whole innovation stage that he'll never be finished and is always trying to perfect what he is doing. And maybe sometimes there are different types of people, and maybe getting to 80% of the answer is most probably good enough... This is how research goes, you don't always have to be 99 percent correct in what you do. Somebody else can actually take a concept and show you where the trend is growing, so 80% is good enough. So I think they must be allowed to roam and that is where we come back to the first point that when a guy gets stuck, that he comes and asks you but ideally you want him to him to self-explain as far as he can. But the guys must be allowed a certain amount of freedom	C6
92	EITelkBF IL: what some people like to do is to play a power card. When you get to a certain level and the problem is in a certain way not being able to say that I have stuff up. Didn't people then get accused because they know more technically than the other people and the other people then feel threatened... Maybe sometimes accept, saying how and when the solve it and move on in life. Don't become defensive	B5
93	EITelkBF SH: People that work down the organisation can add value because they know how to do things. The people who add value to my life actually contribute their true-life experience so that you can benefit from that	C2
94	EITelkBF VR: So, it is all about the principles of business, very high-level principles and less about the numbers that actually sit on the bottom	D4
95	EITelkBF IL: The problem he as a project manager has to understand is how hard doI push that guy and how hard I push that guy. Sometimes we get to the story of the value chain and you ask who actually leads the process and I always try and explain in our company when it comes to that portion of the value chain, that person actually takes control... But I mean the boss of the top level will probably still set the pace. But it is hard to actually say who is in control of the project and different points	F3

96	EITelkBF IL: You got different degrees of centralisation, so let's say you had a five-player network and you start to centralise at layer 4, you know longer need a whole pile of different channels and the concept, based on the cost of bandwidth dropping, the more demand you can create the more the economies of scale start working in your favour. So, in principle if it becomes cheaper over distance in theory it almost becomes a new relevant portion with less costs.	D4
97	EITelkBF IL: That is incredible and has changed the whole landscape to where you can now interact with the whole world if you think like that. The problem is: Do we actually use it optimally, and I say this because we can always use it better, in your environment you will say I wish I can use it better but the problem is you just don't know what you have to do to use it better, so you are not aware of the underlying principles involved.	A2
98	EITelkBF LM: The free thinking and out of the box thinking, they could think beyond how things are being done at the moment. In theory it gets you more to the concept, like on your sketch, it gets you to this portion of where you should actually be. You always think short-term, in terms of how could we do it faster. Problem is that you then miss the bigger picture. So that's what I'm saying the larger the organisation, the more to me essential it is that a small team of free thinkers is set up with the capability to work through all the domains.	C2
99	EITelkBF LM: Tell me what you want and I will make sure you get it. So, I use this almost as a fear factor so the guy almost gets scared of me and does what I ask him to do. So, anybody will almost give me exactly what I want, so that's why I'm just asking the guy what he wants because if I know what he wants I can give it to you. The problem is those things become disruptive in the longer term in terms of what you are trying to do. That's why I as a manager I must try and keep disruption away from the working members and I try to handle it myself. That keeps them focused and does not break their concentration	F6
100	EIEohGL VC: this idea can be sparked by a conversation with a customer, or by people in the industry who knows the space. You know it is very seldom that I've seen somebody just deciding to come with the next big thing already knowing what it's going to look like	B9
101	EIEohGL VC: So, in the digital space obviously it is evolving very quickly. The market moves on very quickly. We cannot afford to make assumptions or to say this looks like a good idea today and it will still be a good idea tomorrow	C9
102	EIEohGL VC: Work on the assumption that somebody has thought of this already and we have to do it better to make sure that there will be some advantage, like a competitive advantage, some leverage area, whether it be competitive differentiation, access to market or others that will keep us in business and give us something to build on that will keep us ahead of the competition.	A10
103	EIEohML VC: It becomes more and more difficult to retain people in positions for long periods of time. They do great work but they want to leave to take on another challenge. And my long service employees cannot deliver the new things needed, that's why we're going for this Internet model. That is why I would rather go for the architect model that I referred to earlier. For that I need requirements in the architect to design a solution and I am no longer dependent on developers of software. The city and develop things that no one can use, and they incur direct and overhead costs without contributing value to the innovation. And the capacity in South Africa, we are running out of capacity.	B6
104	EIEohML VC: This legacy ...came from what we were doing in 1948 and the ability to continue reinventing ourselves in light of changes in the environment and changing the rules. PWC changes what they need reporting on, the CAs change what they need in reporting and we have to stay with them. So, we need to innovate at levels that keep as attractive and not risk becoming another bank, because we are not a bank. We are technology partners.	A5
105	EIEohML VC: Somewhere in your portfolio "...*gaan jy geld weg bliksem*" but do not design your innovations to become lost leaders. When things don't go the way you anticipate it, you have to decide on either stopping or putting more funding behind it, so the ability to read financial calculations throughout remains critically important	A7

106	EIEohML VC: If we look at the type of people we employ, in the 80s we employed propeller heads with large egos and scarce skills, they were not nice people generally and it was difficult to communicate with them or to get them to think in new ways. They thought they knew everything and they did know a lot, but today I go to the Internet, place my requirements and I get 50+ responses rapidly	B6
107	EIEohML VC: To have very strong competencies in your people to complements your own, because you will have to persuade executives, and customers, and others that the return be greater than the costs. You have to optimise all the time by understanding all the cost elements and cut down on waste where possible.	D2
108	EITelkSL VC: Focus on the right things, creating the thing that has got value to the business or to society, it is having some enthusiastic people that can innovate and I think it's about forcing it into the system so it can be used and we can call this marketing or whatever. And I think you've got to have excellence as well. And people who want to win. To me I think those are my insights and I hope that makes sense	B6
109	EITelkSL VC: Lab it's about setting up the right environment because without it people get stuck	C2
110	EITelkSL VC: It can fail because you don't have the marketing competence where you have the idea but it is not going where it should because of inability to link it with the market to use it.	D2
111	EITelkSL VC: Once it gets used by the market you get feedback and you improve it.	E5
112	EIDaVRM VC: remember from the (confidential) about that tagging technology and how they screwed it up here and then it went over to Britain and you know I think it is also about applying this linear thing. Here are the criteria for a successful technology, here are the things that you need to go through and they are doing it and I'm saying but, hey, there are new tools now for the example that they call RMA, rapid market assessment where you actually sit down and say the technology looks quite exciting but you have seen much of the stuff, things collapse because there is no market and when you see now is that tools like rapid market assessment on being applied because it indicates there is hope, then you can turn around and go to investors and get them to understand there is potential here.	E1
113	EICokGW VC: Innovation is something new that creates new value, and if those two conditions are satisfied you have innovation	C10
114	EICokGW VC: well that is what the people think. It is what others say about the value that you add, that is what counts.	D2
115	EIEohML VC:at the larger corporate (confidential) you will notice a lot of innovation in a lot of areas. We still innovate but the game has changed and so has our business model.	A10
116	EIEohML VC: We make fewer terminals because they are more powerful and we cannot really compete with the Chinese on commodity level mass manufacturing capability and pricing. For example, the little sensors that we use (=Value)	D4
117	EIEohML VC: The Chinese provide the little sensors but everything sitting behind the sensor is our area of speciality. How this thing talks to payroll, how it links to a SAP or Oracle that's what we understand, and we understand both the hardware and the software elements making up the system. It is no longer stand-alone device driven, there are so many areas of interfacing with other systems and we have to be good at the integration of all this (=Value proposition)	C6
118	EIEohML VC: But it is still too expensive, we can prototype with it but we cannot roll out to 3000 stations. So, we need to plan some type of technology S-curve.	E8
119	EIEohML VC: So I cannot persuade a customer that he has to switch over when he is still getting the benefit from the old machines	E2
120	EIEohML VC: So, some of my software and firmware will be outsourced increasingly to developers that could sit anywhere in the world and who could be selected to serve a particular need in a particular time frame and within a particular budget range. Sometimes time is not important so I can afford to take more time but save on budget.	C6

121	EIEohML VC: Competition has become so fierce that some will even submit proof of concept stage technologies for my consideration. You will easily get 50+ responses to an ad and the majority of these can operate at high standards levels. You can easily pick five offers at proof of concept stage without any financial claims by the provider	B1
122	EIEohML VC: We have reduced our R&D budget from R17 million to only R3m, and that includes total expense like their salaries, equipment and even they office space that they occupy.	D8
123	EISasTD VC: You can't just talk about the idea and innovation. You need to work from the idea through to commercialisation or implementation and you need to understand what it take for me to take it from one stage all the way to the commercial environment	F10
124	EICsir RC VC: as a scientist with basic understanding of nanotechnology chemistry and physics, the behaviour of the particles, to give them a chance to think of what difference they can make to industry. So, in a short space of time he has come from being a scientist making his scientific knowledge and that of his team work for industry	D2
125	EICsir RC VC: When a leader is behaving like that, do you ask him what for? No, you would rather say if you need more senior scientists, go and get them. So that is what makes him different.	F4
126	EICsir RC VC: His supervisor was also a brilliant mathematician, physics and all sorts of things like that, who said that it is so difficult to work with so many things but this young person listened to the challenges and went and tried it and tried it persistently. And then one day he walks into his boss's office and says come and see this... And the boss looks.... And he looks and he says to this youngster do you realise what you have done? Yes, I think I have done it. As simple as this, persistent and being allowed to do it, being given the space to do it	C3
	Capability cluster 5: Facilitation of value realisation (VR)	
127	In telecommunications you get these start-ups that get money from somewhere to do what the money is intended for all they go in the opposite direction and eventually get bought out by one of the bigger characters	E1
128	EICsir RC VR: He actually built a pilot plant if you walk into it it does look like a factory where he makes samples in the packages it, he makes these things look like things you can buy off the shelf. That's him. So, he goes there with his 'gung ho' attitude which makes him convincing to his clients. The manner in which he is convincing is not by explaining his art, it is about demonstrating his art.	D1
129	EICsir RC VR: Over time he will iteratively get it right and with a little bit more time you will get its products to be better than the goal or standard but he lets it down anyway. His research is then informed by the crude things which he is dumping and feedback as the product is shaped for delivery into the market. He is able to, from a distance, assess the progress.	F10
130	EICsir RC VR: So, you need to show that you understand that full cycle. The model must talk to all the different facets required to take this thing through all the stages into full implementation	F10
131	EIEohGL VR: We are quite lean, we typically try to take it into a market where we know we have a customer already, learn from that. You know it is very easy to test things by just asking questions. At best we would do a proof of concept that we would pay for but after that it would be paid for by the customer or somebody and we would develop on the back of that until we know it successful and we can further pursue it.	E2
132	EIEohGL VR: We need to make sure that person has access to the right skills, we pull skills from across the business. This could be technical skills right from UIF(?) through to database, real hard-core coding, to develop the product, to test it, to get real traction and develop the back end.	D2

133	EIEohGL VR: So, I'm quite happy to get the assumptions wrong. I am not happy to get the investment wrong. Because if the investment is wrong and we thought our assumptions were right we've got to continually test. By visiting our original game plan and say is this viable. If it was viable but now looks less viable because someone else has entered the market with something similar and you're going to lose your advantage, then you call a spade a spade.	E7
134	EIEohGL VR: It may be that we need another version of this thing that we haven't thought of yet, so it's constantly checking, asking questions to make sure that you are not working on assumptions.	D2
135	EIEohGL VR: We are fortunate that we have a very considerable skills pool that we can draw on and I think also if you're working on the principle that the best chance of success is when ideas are driven by passion	D5
136	EIEohGL VR: We can't be sitting and see ideas go by but we have to test if this thing reveals our initial assumptions were wrong, the opportunity we thought was there in fact does not exist. In a way it can be interpreted as failing but in a way, it is success. Our test has proven that our assumptions were false and we therefore are not going to pursue it so this was a success in its own right. We did not for a fortune of money into something we would don't know what the outcome might be.	D6
137	EIEohGL VR: We do follow approaches like, I don't know if you've heard of this, lean start-up? So, we do follow those methodologies in our thinking, sometimes we do them in a very structured way and we will even do the business model canvas. Sometimes we have a paying customer for something so we could develop it on the back of that.	E1
138	EIEohML VR: when I took over, there were promising new ideas and technologies but there was no indication of "*waar de moer gaan ons die ding verkoop*". And developers building incredibly impressive software without any consideration of what the client would perceive as value	E2
139	EIEohGL VR:EICokGW VR: The something new could be an idea, invention or a new technology but if it does not create new value it remains an invention and not innovation...value then would be seen as very broad as well. It could be shareholder value, value for the people, the community and it could be value for the planet.	D10
140	EITelkSL VR: So, we measure at a thing called NPS, which measures how satisfied a customer is and you get a score. So, they have what we call daily huddles where they talk about the worst one and the best one to see who becomes the champion for the day.	F4
141	EIDaVRM VR: in this more warm and fuzzy environment they are also breaking away from a lot of the traditional ways of getting a technology into the market. So, you are seeing now lots of creative ways of setting up the license agreements, of selling the technology.	D7
142	EICokGW VR: This is where the brand marketing comes in, emotional component, and make an effort which is where the social element comes in. It is thus about making a difference and as such we create value.	D8
143	EICokGW VR: When we find there is scope in the market we acquire and establish it as a venture in emerging beverages. These people don't invent beverages but they apply new beverages when they introduce new beverages into our system and do the scaling because it is something new.	E1
144	EIEohML VR: We started using computerised time and attendance systems where data was captured electronically for processing by the computer. A lot of small companies became involved that were later taken over by ourselves	E1
145	EIEohML VR: We create technology solutions that satisfy customer requirements and then we put our leasing package together to assist the client in scaling the use of the technology to desired levels of efficiency and operability. So, our innovation combined technology and the work that financial institutions used to do, so our innovation moved from technology to also include the delivery of the technology and making the adoption of the technology affordable for the client.	D8

146	EIEohML VR: These are all driven nowadays by customer requirements and less so by the technology possibilities. We have to be innovative with available technology and be aware of new possibilities but it has to be integrated around customer benefits and what they value	B9
147	EIEohML VR: It is no longer stand-alone device driven, there are so many areas of interfacing with other systems and we have to be good at the integration of all this. So, for instance, I cannot deny a user access when there is a fire; so there must be a link to the building management system that the user can still make use of even if there is a fire. Fire systems linked with alarm systems with links to access systems are good examples. Then there are new developments around carbon tax, so we have to be aware of that and help the customer to optimise. In practical terms this might be a light indicator for the last person leaving the building to switch off the lights. So, this integration at that level, everything has to be created. You buy one component from Honeywell, and another from somebody else and when we take the integrated product to the client, all of these have to fit onto one computer screen. So that he can press buttons to open doors or activate other devices	C6
148	EISasTD LM: In an environment like Sasol you will always get the question of how much money this is going to make, when are you going to have it, and how much is it going to cost us to get there? That's a question you will get all the time. Now what happens is the really bright ideas, the higher risk ideas, when asked the question about how much money is going to make for the company, you choose a number and executives don't like that because if you say 1 billion they are going to hold you to that. But you don't know, you really don't know, and when they say how much this is going to cost you, you choose another number, and how long is it going to take and again you say I don't know the answers, then you are really looking at high risk with uncertain returns and that will not be approved. Because you are asking the wrong question. In my view the questions you need to ask should be based on where you are in the development cycle... . If you ask these questions at the wrong time, you will kill it. You need executives that understand the innovation processes. Innovation leaders understand this, but executives don't. I'm not being judge mental but these are the real issues...	B5
	Capability cluster 6: Integration through leadership (IL)	
149	EIEohGL IL: We work very much on the principle that we have each got different roles. Because my role is to coordinate the troops it does not mean my ideas are more valuable than theirs. Or any different from someone else like a creative director or developer or whatever. So, my role is to coordinate, pick up these ideas and make sure people are empowered and they get what they need. EIEohGL IL: We work with people that we enjoy working with, and for us this is more than just a job. And I have to help my team to be successful, and that is my job.	C8
150	EITelkSL IL: The leader that you don't want is the one that is stuck to his own ideas and did not recognise the other ideas. The ideal candidate of course would be the one who synthesises the best solution from a combination of his own and other ideas. I think that is quite important.	F5
151	EITelkSL IL: For innovation to work in an organisation the leaders have to allow it; . You have to be open for it	F1
152	EIEohML IL: In terms of management skills you have to also be very open, you must be competent in dealing with a whole diverse range of people.	F1
153	EIEohML IL: Patience you will need a lot of. If you look at my leaders you will find that they are good at what they do. Some of them have been with me for a long time and we have learnt to work together	F7
154	EIEohML IL: He has unbelievably good skills to communicate well with the team and he gets it right to motivate them to innovate and to keep them busy with things that motivate them	F5
155	EIEohML IL: This generation is extremely mobile, if you fail to keep them occupied and motivated by things that matter to them, they will leave you. So, these are special skills of the leader, skills that come from knowledge. And you cannot buy the skills from a CV.	F3

156	EITelkSL IL: He had a vision of where things are to go, and he believed in it and created the new reality so he was very demanding of people set very high standards and I think was able to command that, he could see the future but also, he could drive people and obviously he was able to select good people and ruthlessly threw out the wrong people.	F2
157	EIEohML IL: So this is where we are, what innovation is heading towards in terms of strategic focus.	F2
158	EIEohML IL: The conversation with your staff is to check if they find this interesting and challenging enough and what they need to make it happen to make sure that you support them. Ask what else they would put on top of it to make it more interesting try to accommodate that	F5
159	EICokGW IL: Started with the basics, developing the nomenclature, developed the language and established a range of platforms for the innovation conversation... so that we could talk to each other and understand innovation conversations we can all at least talk and think about it in the same way. And then connected the conversations to the mission and the purpose of the company.	F10
160	EICokGW IL: This is where I came up with a framework that I referred to as the house of innovation. And the house of innovation has many rooms and every room has its purpose and function. These functions are connected and somebody needs to be the architect to make sure that the house does not end up with three kitchens and no bathrooms meaning that you don't have parts of the organisation doing the same things because that is waste. But also, to make sure that there is a way to make sure that you activate new opportunities for innovation in a complementary manner	F10
161	EISasTD IL: You need people, you need resources and all the other things that you require. You need people you need infrastructure you need funding you need partnerships because that is what makes it happen. But at the systemic level, if there is no governance, you will get chaos. You will not get the impact you want.	B4
162	EISasTD IL: Proper governance talks to the strategy. There is one other important element here which is the visibility of the portfolio, and this should be in the model, how you manage intellectual property.	B5
163	EICokGW IL: You create a Department or a group of people or an initiative where people work together to activate innovation for a different purpose. For example, R&D which is the classical instrument for innovation by doing research and ultimately product development. Here research is a room, development is a room and commercialisation is a room. We have the whole marketing department and digital marketing group within that and ventures group with social ventures in it	F10
164	EITelkSL IL: He was courageous enough to be bad so when he had a team designing the MacBook it was supposed to be light and thin. So, it had to lose a lot of functionality in the process. So, in order to innovate you need to make choices and I think he was able to do that. And he was able to transition beyond what it is. So, it is also about knowing what not to do.	D5
165	EITelkSL IL: He was asking somebody a question which they were not able to answer and then got fired. He was a ruthless to innovate	F5
166	EITelkSL IL: When I took over they were under pressure as they had to keep cutting costs because people didn't really believe that they were doing anything valuable... the first thing was to understand what they were doing and what they were successful at. They were successful at testing it wasn't that much linked to innovation. They had to deliver value 10 times what they were costing	E9
167	EITelkSL IL: The only way we would take on a project would if a few rules had been applied, like they had to be a committed and enthusiastic owner before we would take on the business, someone who would champion the idea all the way through	B6

168	EITelkSL IL:VC/IL Between the guys in the labs they came up with something quite quick because their skills were quite appropriate. They created something called exact which would take information from all the various systems delivered an integrated service. This happened real quick and they were showing value... We had the champion and the guys were really enthusiastic and it was like a rugby team who really wanted to win. And from there on they added more value. It probably started 8-9 years ago and they are still applying this model.	D1
169	EITelkSL IL:IL the people that were there believed in this and it was a great opportunity for them so for engineers who wanted to do stuff, they were fulfilled, so they were quite excited and obviously worked long and hard hours, extra hours and being very excited. And then we also had the business to take it along.	F8
170	EITelkSL IL:VR So there were also a lot of articles about the labs and what they were doing so people perceive them to be adding value. And when we had the system we had it marketed and said guys this is what we are doing and why it's important.	D2
171	EITelkSL IL: IL we of course applied these things before we knew about Steve jobs so I think these were just similar themes that came through	F7
172	EITelkSL IL: I read through his thesis and he comes across as very confident but the environment was there, the equipment, the oscilloscopes... The money to invest in the robots was available so that was all there and he was able to innovate. It was tough but he did it. So, the leader has to create the environment. That's probably the key for me.	C7
173	EITelkSL IL: You know with innovation I also believe there is a need to allow people to fail. You shouldn't have to succeed, let's say you take on 10 projects I think it's a bit like venture capital. You are not likely to succeed in all the projects and when you do not succeed you probably have to be willing to close it down. I think that is it. I don't think failure is necessarily bad.	F4
174	EITelkSL IL: I've been picked to do it because my boss is the COO and if the COO believes I can do it, I can bring all the skills and things together for innovation, but I am finding it very challenging because I'm not a equipped for that... let me explain this, and I mean there are days when I feel like this is too much	F5
175	EITelkSL IL: And is still a problem because of the broken trust. I'm trying to rebuild the trust but I am battling	B1
176	EIDaVRM IL: So, they are finding that this concept of engagement is absolutely critical and there is a concomitant issue around that and that is generating this notion of ownership, that the leaders are creating an environment and this is not shareholding, they are creating an environment where people feel that they want to be able to go in to that organisation	F3
177	EIDaVRM IL: They almost look at the organisation as if it's their own and that is done by many many ways, it is done via reward, it is done by recognition it is done by creating a whole lot of different incentives which is by the way very sadly lacking in this country.	F6
178	EIDaVRM IL: One of the most frightening things in this country is a lack of recognition and rewarding for innovation	F6
179	EIDaVRM IL: There is a company here in South Africa where the leader turned around and realised they were totally reliant on five people in the age group 28 to 30, whizz kids and they were developing lasers. . John was an interesting man because he said I cannot prevent these kids from actually leaving this company and setting up their own business so he pre-empted this. He went to each one of them and set up a business, he paid to set up the business and took a 50% share in the business and he then gave them a guaranteed order and they became managing director's because realised these entrepreneurs in the end would not be willing to work for the company	F6
180	EIDaVRM IL: The reward process is also something which you simply cannot ignore...[example of host going to office if he wants to] he said we have a policy in the company for any scientist or engineer that has a massive breakthrough which is commercialised by the company you get a royalty for life. So I asked what did he do and he said I developed the glass top stove... . He's got an arrangement with the company that he is bright and comes up with ideas. So the rewards thing is critical and the leader has to be able to design this.	F6

181	EIDaVRM IL: What you are seeing in highly innovative ways of actually rewarding such as you will get a percentage of royalties or I will give you the opportunity to begin your own business or I'm going to give you an opportunity to begin your own division in the business. So, it is status, it is monetary it is around making people feel very special and welcome in the organisation.	F6
182	EIDaVRM IL: These leaders are agile, they are incredibly adaptable and able to really switch from one strategy to another and they are in tune with what is happening in the market place.	C9
183	EIDaVRM IL: The other critical thing is of course is the ability to partner. Partnerships are absolutely ingrained in these people, this notion that, and it is very much an exciting philosophy	B5
184	EIDaVRM IL: You know the more this country gets bogged down with corporate governance the more we are stifling innovation.	B5
185	EIDaVRM IL: CEOs are terrified of moving away from the business plan and what we are saying here is that these guys are actually able to design flexibility into their business plans	C9
186	EIDaVRM IL: The business plan is not perfect; the business plan is delivered to the board on the bases of this is what we are happy to do but the technology game can change and we can we taken out by technology changes overnight.	C9
187	EIDaVRM IL:. It is the market and the psychologist issues that are so critical and I think you've hit the nail right on the head. It's around the warm and fuzzy stuff to make people feel hell of a good and at the same time it is around the commercialisation process, which by the way is one of the most worrying things about South Africa. And that is this appalling inability to commercialise.	D6
188	EIDaVRM IL: How do you manage Propeller heads? And how do you create the environment in the organisation in which these way-out of people can come to work in sandals and stuff like that while at the same time as you know, what was that author's name... They pay like slot machines. When they hit the jackpot they pay like slot machines.	F5
189	EIDaVRM IL: There is of course this issue about managing by fear. So, if you read the Harvard work on managing by fear and turn around and you look at Apple... You know Steve Jobs operated like a total autocrat, as a total autocrat, he was ruthless. So, in many respects he was managing by fear	F5
190	EICsirJIR IL: sometimes people create the image or impression that the leader of the innovation process is someone that is really so open-minded and there is no order and it is just all over the show. I view it slightly different. The people that I've seen being very successful that have seen innovation through as a strong balance between order and discipline as well as open-mindedness to make sure that the process actually flows and that there is progress from the early innovation stages to the commercialisation or industrialisation will impact or whatever you want to call it that follows.	B9
191	EICsirJIR IL: Sometimes you may have it in the team but I believe that for the technology innovation leader that balance is very important, and the discipline that goes with it. So I think it's the issue of being focused but at the same time about understanding the bigger picture and understanding the processes needed to take you where you are going.	A10
192	EICsirJIR IL: Probably more my personal approach, not to actually over design the process or to make it too complex. That you see also quite often that leaders become so involved, I see it in my own environment as well, that people applied textbooks and design processes making sure that everything is done by the book in terms of the right team in the right activities and all of that believing that you can't really deliver if you don't have this and this and this... Process in place as per the textbook. Well I think there needs to be much better balance between their design and all that, somewhere you need to strike a balance because otherwise you will run out of resources	D4
193	EICsirJIR IL: I think it is more at some stage about starting to get your hands dirty moving into the innovation and making progress just by doing it and start to learn more from that and I can think of many examples where you actually see the results of something that is successful	D1

194	EISasTD IL: In R&D you must be able to forgive...because if you are unable to forgive, you will have a problem. And I think basically it says you must have an appreciation that there is knowledge gained in failure	F7
195	EISasTD IL: If you are sitting in the senior position as leader and you think you know it all, you could find that this is a very big mistake. Because when you have that mentality, you find that people are good at what you know, you give them the space to be good at what they know. If it is the opposite you will always want to tell people what it is that they get wrong.	F1
196	EISasTD IL: To be really good at leading technological innovation, you need to be strong at technical skills and leadership skills. Because if you are just technical, you become a specialist and not the leader to fulfil a leadership role. If you just have leadership and no technical, you cannot set a strategic direction... it's very similar to someone who is a conductor of an orchestra who can't play all instruments. But he can see and tell when one of them is out of tune.	F1
197	EISasTD IL: I must be able to go and sell what you guys are doing to the senior leadership so that they continue to invest in you, so I must be able to sell the value proposition and make it visible to senior leadership. So, it comes to communication, reporting and ensure that all those things that you do remain visible. So, I must create that environment that allows for those things to happen.	D8
198	EIEohGL IL: I come from a world where you try different things and fail fast. It's a case of coming from the entrepreneurial world where there is probably less structure, and an understanding that any idea is probably not going to be truly original because of the information or knowledge economy.	E1
199	EICokGW IL: I am not trying to control everything, absolutely not. It's more about making it inclusive in a non-threatening way. And of course, this is a journey where you will never have full control of everything	E6
200	EICsirJlR IL: Technologies that weren't commercialised or establishment of programs and initiatives where I believe it was a good balance between design of the process in the resources to get the job done and learning from that to rather spend more time, perhaps instead of 90% of the time spent on design rather spend 40% of the time on design and rather get going improve the design as you learn.	E9
201	EICsirJlR IL: The whole thing of collaboration networking communication, that capability, in my opinion is good if it sits in the leader who can strengthen it obviously with the team.	B7
202	EICsirJlR IL: That is a capability in the individual just being able to reach out, to listen, to collaborate... It brings so much more to the table. They need to be able to do this and not feel threatened... Threatened in the sense of being willing to learn, in other words not to think that I know in all and therefore I don't need to talk to others, but being able to sense that this person or team knows where they want to go with innovation but that the are still willing to take inputs, learning and ideas...	B7
203	EIEohML IL: The need has changed our innovation model has changed although we've kept much of our innovation culture and legacy competencies in place.	E5
204	EIEohGL IL: There is recognition throughout the process there is recognition in the form of financial, public acknowledgement of good work. Different people are motivated by different things. Some would prefer a more altruistic reward like for the benefit of society, and they'll do it without financial rewards. As people are motivated by being acknowledged and seeing the ideas work. And it takes all kinds to make this world tick	F5
205	EICsir RC IL: Present with the team, constantly. His levels of energy and enthusiasm are kind of infectious, he has got enthusiasm about his work. Where I have seen leaders of equal intelligence he is head and shoulders above them in the sense that he does not let bureaucracy, systems and processes bring him down. He finds a way of making it happen despite things that might be viewed by others as encumbrances, he works in the CSIR a similar environment where others are stressed and depressed that things don't work and he's just achieving it.	F8
206	EICsir RC IL: So that confidence, their self belief is a key attribute I think makes them successful.	F1

207	EICsir RC IL: You get these many ideas and you touch this, that and the other than those who are successful create some order, establish some pathways to set a very clear end point. It is that discipline to focus and put things in order that makes them achieve success. I don't think they achieve success randomly with brilliant ideas just coming together, I didn't think so.	F10
208	They got this guy on board and became one of the leaders in the field... But he can talk to anybody at any level, and talk to you, the head of a company. To him he is not worried about this process thing and he talks to people at all levels.	F1
209	The leaders of innovation are adaptable they can actually interface, to them it's not like a status thing. I think those people tend to learn from everybody in the company. Whether it is a person at the top or a person at the bottom they will say give me the problem and they will tend to learn from others	B1
210	EIIfBvS IL: Inspire others to higher levels of performance	F2
211	EIIfBvS IL: Create the environment where people can first and foremost be themselves	C2
212	EIIfBvS IL: Allowed to be themselves they will feel free to express themselves, be creative and to contribute to innovation	F4
213	EIIfBvS IL: Create an atmosphere where people feel safe and are not worried about feeling silly, being ridiculed, or undermining their professional standing through suggesting crazy solutions and ideas	F4
214	EIIfBvS IL: Provide the context and some guidelines on where to go	D1
215	EIIfBvS IL: Leaders who determine what is acceptable and what is not acceptable in an organisation	F1
216	EIIfBvS IL: Model the kind of behaviour that he would like to see	F1
217	EIIfBvS IL: Not only provide direction for those whom they expect to innovate but also create an environment in which innovation can happen	C2
218	EIIfBvS IL: Bring out the best in others in all senses such as their ability, their self-worth and what the individual can achieve in life	F5
219	EIIfBvS IL: Moved away from worrying about how good I was to what contribution I might be able to contribute, what I may have to offer	B6
220	EIIfBvS IL: Focusing on what you as a leader can contribute rather than what is in it for yourself is what enables you to bring out the best in people and the way in which they use resources	F5
221	EIIfBvS IL: Leadership for innovation happens at all levels and it is not directly tied to the hierarchical levels	F4
222	EIIfBvS IL: Executives are in a position to create an environment for innovation at an organisational level.	C3
223	EIIfBvS IL: It is not so much about being innovative as an innovation leader but rather understanding what it takes to create an environment that is supportive of innovation, and making it happen	C2
224	EIIfBvS IL: But if it [innovation] is not understood and supported by top management, it is unlikely to happen.	F5
225	EIIfBvS IL: Have innovation competencies embedded throughout the organisation.	D5
226	EIIfBvS IL: ..are always open to new thinking and are trying to figure out what is next.	A10
227	EIIfBvS IL: Understanding it with your mind is not enough, you need to understand and feel it in your heart in order to change values and behaviours.	F5
228	EIIfBvS IL: As a leader you have to understand innovation, and create as well as open doors for newness to come in	F5
229	EIIfBvS IL: Awareness (of context, circumstances & complexities)	F7
230	EIIfBvS IL: Appropriateness (of choices and approaches to the task in question)	F2

231	EIIfBvS IL: Alignment (of the different aspects of the organisation's to its innovation ambition)	F2
232	EIIfBvS IL: Appreciation (of diversity and differences in preferences)	C3
233	EIIfBvS IL: Attitude (leading by example and being open to ideas, especially crazy ones)	F1
234	EIIfBvS IL: We need leaders who can hold it all together, that is the views of the psychologist the engineer and the marketer	B2
235	EIIfBvS IL: It would be a mistake to try to make everybody the same; we need those with deep levels of expertise, and we need those who can communicate 'across communities'.	C3
236	EIIfBvS IL: Create a context where each can contribute according to their area of expertise, and is appreciated and respected for that	C10
237	EIIfBvS IL: What do we do and can we as leaders do to make or help those with different values and mindsets work together better?	C10
238	EIIfBvS IL: If values and mindsets between those we expect to collaborate are very different, as for example between scientists and marketers, there is normally a struggle to get to work together successfully and in a way, that truly brings together their different areas of expertise that results in something new and exciting, rather than something that reflects the lowest common denominator	B7
239	EIIfBvS IL: It has become impossible to solve some of the problems by applying the thoughts of any one particular discipline.	D9
240	EIIfBvS IL: It has become necessary for these different perspectives to be acknowledged in order for leaders to ensure that the best thinking is applied	D9
241	EIIfBvS IL: If we are too familiar with a particular context we can no longer see potential and possibilities that goes against accepted wisdom in that field.	C3
242	EIIfBvS IL: Get people from different contexts involved to help them see what they cannot see themselves	F2
243	EIIfBvS IL: Previous [management] models were more likely to try and bring everybody up to the same level, working on people's weaknesses rather than allowing them to focus on their strength.	C2
244	EIIfBvS IL: Able to tolerate different perspectives	C2
245	EIIfBvS IL: This is fundamental for innovation, we have learnt wrongly that there is one correct way and therefore people who are not following this one correct way are wrong and should rather not be listened to.	C2
246	EIIfBvS IL: People are employed and rewarded for knowing and applying the recipes we already know, yet innovation expects them to share and work in teams who have knowledge of other recipes but we would rather reject those views than to integrate them with our own thinking. This is where leaders can make a huge difference	F6
247	EIIfBvS IL: You get leaders who say they stand for innovation but regard those with different views as troublemakers and underperformers. Innovation leaders should look for what is required to engage people and empower them to innovate	F4
248	EIIfBvS IL: Make people experience what it is like to understand and appreciate other ways of thinking before people will accept that there are better ways of thinking than the ways in which they have been thinking before	C1
249	EIIfBvS IL: It's very hard to find someone who is equally good at everything from start to finish in an innovation's journey	C1
250	EIIfBvS IL: Not everyone who has a great idea is equally great as project manager	C1
251	EIIfBvS IL: I also think there isn't just one style for leading innovation. If for instance, one looks at Steve Jobs, he was probably not always the easiest person to work with but people were willing to forgive him because of the inspiring vision that he had	F2

252	EIIlfBvS IL: Innovation and R&D are not the same. Kodak were very good at what they were doing - they just did not take the new developments at the fringes of their industry seriously.	F2
253	EIIlfBvS IL: One of the problems confronting innovation leaders is that we tend to present innovation as if it were happening in linear sequence when in reality that is not the case at all.	C9
254	EIIlfBvS IL: Be careful not to assume or imply a linear sequence and rather focus on the dynamic interactions	C9
255	EIIlfBvS IL: Be cautious in selecting bullet-type descriptor words that may not represent the full meaning of what leaders do to support innovation.	F3
256	EIIlfBvS IL: Sometimes a small change in nuance has huge difference in meaning	F3
257	EIIlfBvS IL: Looking at the world and legacy that they will leave behind [innovation leaders]	F1
258	EIIlfBvS IL: With words we always tend to assume shared meaning, with pictures this is not the case. We can interpret any picture in a number of ways. This means that we need to share much more of our thinking, of our tacit knowledge if we communicate with the help of pictures.	F5
259	EIIlfBvS IL: Innovation is the consequence, not the driver. If you keep people inspired as an innovation leader, your people will get to innovation. You do not have to tell them to innovate.	F10
260	EIIlfBvS IL: The key in leading people to explore novelty and to share their learning from their successes and failures. And trust and respect [relationship] are absolutely essential for 'across community' collaboration.	B1
261	EIIlfBvS IL: If things are too easy to achieve, people would simply not be inspired because it is like business as normal. If the reaction is, "no we cannot do that … perhaps we can!" you are on to a winner.	F2
262	EIIlfBvS IL: Innovation leaders are highly connected and open to find new partners with whom to innovate	A2
263	EIIlfBvS IL: If everyone understands and buys into innovation, then you don't need much of a champion any more. You don't have to be the hero running in front if everybody (in the team) is already running in the same innovation race.	B1
264	EIIlfBvS IL: Rather call this [gatekeeper] a connector rather than the gatekeeper. Gatekeepers may be perceived to keep things out while connectors tend to create synergistic relations in the way they put things together.	F9
265	EIIlfBvS IL: The buzz [energy] is critically important for innovation. I support Rosabeth Moss Kanter who distinguishes between positive energy spirals and negative energy spirals in organisations. Clearly innovation leaders create upward, positive energy spirals.	F8
266	EIIlfBvS IL: Put the emphasis on the non-monetary rewards and particularly recognition. Monetary becomes more important when you have created a multi-billion operation from your idea; you have to share in the benefits of this or else people might become very disappointed. Generally speaking for most organisations pursuing innovation, recognition is more important	F6
267	EIIlfBvS IL: Financial rewards that may be counterproductive in innovation if they reward individual, rather than collective or team. Innovation requires collaboration, if individuals are rewarded they are less likely to share and cooperate.	F6
268	EIIlfBvS IL: It may require several attempts and generating multiple answers to an innovation challenge before the winning pattern or idea emerges. Please note there is no linearity here. Unless you try different things, you may not be able to come up with the most successful idea, so this is absolutely essential for the leader.	C7
269	EIIlfBvS IL: I agree with people like Einstein who stated publicly that the engagement of other people had caused his innovations to be successful. Very important also for new start-ups when you have very different people successfully working together because they complement each other.	F3

270	EIIlfBvS IL: It is important for the leader to adjust their behaviour when the context changes and calls for different leadership styles	F3
271	EIIlfBvS IL: Innovation leaders are active rather than passive in looking for trends and patterns. They don't wait to be told.	A8
272	EIIlfBvS IL: Integrative sensing is important and innovation leaders tend to view things and optimise holistically.	F9
273	EIIlfBvS IL: Other decision-making mechanisms may be more appropriate than the leader's ability to make decisions in uncertainty. It may be more appropriate for a leader to trust and delegate to others and have decisions made by them and run with it. They will probably then also support the decision and show the leader that they made the right decisions in taking ideas forward.	B5
274	EIIlfBvS IL: [For big] innovation...the kind of figures generally required will not be available at the point where a decision to make some investment is required. Very often at this point there are no figures that could be trusted or any prior experience to learn from.	E1
275	EIIlfBvS IL: Doing the right thing when the timing is right. Timing is also critical in terms of when and how we approach decision-makers.	F10
276	EIIlfBvS IL: It is important to be able to develop and articulate and inspirational vision of the future. Without it innovation can become a sprint in the wrong direction.	F2
277	EIIlfBvS IL: The leader may not have all the resources to allocate. I prefer thinking of leaders as people who ensure that sufficient resources are made available for innovation.	B4
278	EIIlfBvS IL: Stage-gate type of processes should not be brought in too early because it is likely to prevent people from thinking radically different and the questions traditionally asked at the first gate will kill absolutely everything that is remotely innovative. In the beginning stages it is perhaps more important to understand how ideas relate to strategy, what new opportunities (outside the existing strategy) they might open up, and how therefore might influence the overall strategic direction.	D8
279	EIIlfBvS IL: Production - and that's when you change pipes, that's when it really happens, moving into mainstream. Especially when you have something radical and it does not fit in any one of the existing homes and a new home has to be found for it. I would probably think of a different word as 'production' is too product oriented, and innovation is about so much more than just products.	E9
280	EIIlfBvS IL: Innovation leaders need to stay in touch with feedback from the market place. However, they should incorporate customer perspectives to the innovation much earlier if possible. The most powerful innovation comes from starting with a problem or a challenge in business or society.	E8
281	EIIlfBvS IL: Grasp the interconnectedness of things required for innovation. One of the challenges will be to avoid looking for "this or that" answers. Rather than "this AND that" answers would match the innovation leaders' competences. It is a combination of all these things that matter and understanding their interrelatedness for innovation. It is no longer sufficient for leaders to push push push at one level that they are familiar with.	F10

APPENDIX C:

LITERATURE-DERIVED TECHNOLOGY INNOVATION LEADER BEHAVIOURS

Technology Innovation Leadership Capabilities based on Literature Review				**TilC1**	**TilC2**
#	Stream	Cluster	Description	Code	Code
2	Process	TC	Use several channels to identify the focus areas, including Internal R&D throug☝h systemic and organised technology scanning and competitive intelligence, externally with organisational entities such as customers and suppliers that ask questions and expect answers and solutions, and governance channels such as management boards at various levels who deal with corporate strategy and by implication technology choices for the future (Carayannis & Chanaron, 2007:292)	ATC1	A1
7	Process	TC	Build rich and varied ways of detecting environmental changes or trigger signals that offer innovation opportunities (Tidd & Bessant, 2011:16; Tidd & Bessant, 2013:47; Hoque, 2013)	ATC1	A1
4	Process	TC	Identify relevant networks that will serve as channels of information and news flow to stay abreast of developments in the field (Smith, 2010).	ATC2	A2
84	Lead	TC	Employ research methods and mechanisms to track and interpret new additions to the knowledge base of their discipline or technical domain (Gliddon, 2006:81).	ATC2	A2
85	Lead	TC	Build effective networks to access experts to assist in exploring the potential strategic advantage that technology innovation can bring about for the unit.	ATC2	A2
6	Process	TC	Have good relationships that feed them with intelligence and for dialogue on issues of uncertainty and could fulfil the functions of sounding boards in a reciprocal manner.	ATC2	A3
25	Process	SH	Spot key opportunities from a forest of possibilities (which and why) Ttidd & Bessant, 2011:16)	ATC7	A5
5	Process	TC	Use tools for creating actionable technology intelligence from knowledge outside the organisation to inform strategic technology investment decisions based on linkages to the firm's core competences (Veugelers *et al.*, 2010).	ATC3	A6
15	Process	SH	Detect emerging opportunities, problems, challenges or threats sooner than others to make conscious proactive decisions instead of waiting to be shaped by these changes (De Bono, 2000).	ATC7	A7
26	Process	SH	Make a strategic choice on which opportunities to include in time planning (Tidd & Bessant, 2013:47).	ATC7	A7
30	Process	SH	Set an appropriate, context specific balance for innovation leaders between operations and innovation	ATC7	A7
80	Lead	TC	Instil discipline in project selection and execution through a portfolio of innovation projects with a healthy balance between new possibilities created by scientific advances and projects that focus on solving of problems through new scientific development (Dugan & Gabriel, 2013).	ATC7	A7

Technology Innovation Leadership Capabilities based on Literature Review				TiIC1	TiIC2
3	Process	TC	Maintain high levels of engagement with their external environments to obtain knowledge beyond the boundaries of their domestic base to refine and direct their innovation focus.	ATC8	A8
111	Lead	LMS	Accumulate and build new insights to engage the rest of the organisation and tap into the collective wisdom of the organisation about the orthodoxies that most deserve to be challenged (Skarzynski & Gibson, 2008:77).	ATC9	A9
1	Process	TC	Select R&D activity based on the partners' view of which technologies will be required in the future by product designers, process developers and production experts and the scientific trends that are worth pursuing for the group in order to retain technological leadership (Carayannis & Chanaron, 2007:292).	ATC11	AB
71	Lead	TC	Build rich and varied ways of detecting environmental changes or trigger signals that offer innovation opportunities (Tidd & Bessant, 2011:16; Tidd & Bessant, 2013:47; Hoque, 2013).	ATC1	AB
72	Lead	TC	Detect early signals of emerging changes in the technological innovation landscape and the broader environment that may have implications on the technological innovation being pursued or to be pursued by the firm. It includes the ability to bring such observations into the organisation, synthesise and apply in conjunction with the internal knowledge of the firm and decide whether or not to apply the learning to the firm's benefit (Osei, 2014:116).	ATC1	AB
73	Lead	TC	Establish mechanisms to stay connected with the evolving technology innovation landscape (Spithoven *et al.,* 2009).	ATC1	AB
83	Lead	TC	Build networking capacity to detect evolving technology changes and innovations in the environment (Gliddon, 2006:92; Hoque, 2015).	ATC1	AB
86	Lead	TC	Develop technology foresight by anticipating possible implications of changes in scientific and technology innovation (Steyn, 2012; Elkins & Keller, 2003:588).	ATC11	AB
8	Process	SH	Be able to identify and involve innovation participants from the rest of the firm as well as from outside the firm (Schmitz & Strambach, 2009:231).	BSH1	B1
9	Process	SH	Ensure that different stakeholders become and remain engaged in technology innovation processes because they have different contributions to make and benefits to derive	BSH1	B1
10	Process	SH	Create an environment where ideas are celebrated and everyone in or outside of an enterprise is welcome to contribute, regardless of their position or group or physical location.	BSH1	B1
13	Process	SH	Identify the appropriate stakeholders, secure their interest and support and to establish communication mechanisms for fusing of different perspectives (Elbashir *et al.,* 2011).	BSH1	B1
103	Lead	SH	Build personal relationships with stakeholders whose support and participation can influence the technology innovation success such as customers, supply chain players, policy makers, government, academics and business.	BSH1	B1

Technology Innovation Leadership Capabilities based on Literature Review				TiIC1	TiIC2
40	Process	VC	Begin technology design with a user need and only after witnessing, engaging with and understanding of the user's context, can a point of view be developed to guide the prototyping process with user functionality in mind (Stanford Graduate School of Business, 2013).	BSH2	B2
76	Lead	TC	Recognise signals from dissatisfaction with current situations to desires to make the world a better place (Tidd & Bessant, 2011:25).	BSH2	B2
79	Lead	TC	Uncover emerging user needs that existing technologies cannot address (Dugan & Gabriel, 2013).	BSH2	B2
104	Lead	SH	Develop an understanding of the issues, needs and requirements of stakeholders that could impacted technology innovation intentions.	BSH2	B2
19	Process	SH	Convince others to support the selected opportunity based on understanding of what is to be achieved and the processes involved (Tidd & Bessant, 2011:16,17).	BSH3	B3
37	Process	VC	Support business and marketing by advancing the firm's thought leadership in the global technical and science communities	BSH3	B3
91	Lead	SH	Develop welBinformed advice and strategies that are sensitive to the various needs of multiple stakeholders and partners, reflect the strategic direction and position the organisation for success (Government of Canada, 2007:2; Schiederig *et al.,* 2012).	BSH3	B3
92	Lead	SH	Identify appropriate stakeholders, secure their interest and support and to establish communication mechanisms for fusing of different perspectives. Solicit support of knowledge workers around a compelling vision. Convince others to support the selected opportunity based on understanding of what is to be achieved and the processes involved (Tidd & Bessant, 2011:16,17).	BSH3	B3
112	Lead	LMS	Encourage a heightened state of attention on a future space of possibility that those involved would like to emerge (Scharmer, 2007).	BSH3	B3
81	Lead	TC	Revise and clarify innovation goals, execution plans and technical challenges to adjust their capabilities and resource requirements in light of new discoveries (Dugan & Gabriel, 2013).	ATC11	B4
95	Lead	SH	Secure resources during the early formative stages when hard business case data is not available yet in support of the innovation, including time, money, physical space and knowledge (Almonaitiene, 2013; Von Stamm, 2013; Tidd & Bessant, 2011:25; Bracken, 2013).	ATC2	B4
16	Process	SH	Securing resources during the early formative stages when hard business case data is not available yet, is seen as particularly challenging for leaders (Von Stamm, 2013; Tidd & Bessant, 2011).	BSH4	B4
24	Process	SH	Share innovation responsibility with leaders at different levels of the organisation who individually and collectively set the framework for innovation to happen and consistently integrate the organisation's technical, organisational and creative camps, acting as agents of change.	BSH4	B4

Technology Innovation Leadership Capabilities based on Literature Review				TiIC1	TiIC2
50	Process	VR	Share common resources in support of establishing urban and regional innovation eco-systems based on sustainable partnerships and cooperation strategies among the main stakeholders (Schaffers *et al.,* 2011). It may be argued therefore, that the technology innovation leader needs to be capable of identifying the different resources required for sustainable innovation eco-systems and to establish and maintain cooperation strategies.	BSH4	B4
106	Lead	SH	Obtain strategic alignment and support (cause, time, ideas, expertise and resources) for the envisaged technological innovation area by understanding and relating envisaged	BSH4	B4
11	Process	SH	Create interconnected eco-systems and new business models that encourage creative thinking and problem solving to facilitate rapid idea generation across the enterprise, steer swift development of new and improved products, processes or services that cultivate customer affinity and service dependency and spur higher productivity, performance, knowledge sharing, and growth through collaboration (Hoque, 2015, Muller, 2013).	BSH5	B5
22	Process	SH	Establish interdependency and joint ownership (Bapat *et al.,* 2004:46-50).	BSH5	B5
27	Process	SH	Taking calculated risks is the mark of a good leader and such risk is reduced through information and research over time (Bracken, 2013).	BSH5	B5
98	Lead	SH	Establish interdependency and joint ownership (Government of Canada, 2007:2)	BSH5	B5
107	Lead	SH	Establish governance mechanisms with stakeholders to reflect on innovation plans and progress (Gliddon, 2006; Hill *et al.,* 2014).	BSH5	B5
23	Process	SH	Apply political astuteness (Borjesson *et al.,* 2014, 120)	BSH6	B6
12	Process	SH	Detect and harmonise stakeholder expectations and motives appears to be critical in soliciting support for the envisaged innovation (Schiederig *et al.,* 2012).	BSH7	B7
58	Process	IL	Manage both internal and external conflicts effectively.	BSH7	B7
14	Process	SH	Create an atmosphere that promotes and cultivates innovation (Brands, 2014).	BSH8	B8
18	Process	SH	Solicit support of knowledge workers around a compelling vision (Tidd & Bessant, 2011:16,17).	BSH8	B8
20	Process	SH	Excite knowledge workers through the intellectual stimulation that they are likely to encounter (Swart, 2013).	BSH8	B8
93	Lead	SH	Excite knowledge workers through the intellectual stimulation that there are likely to encounter (Swart, 2013).	BSH8	B8
94	Lead	SH	Solicit energy to overcome organisational inertia and ways of retaining current status (Tidd & Bessant (2013:109).	BSH8	B8
42	Process	VC	Encourage a heightened state of attention on a future space of possibility that those involved would like to emerge (Scharmer, 2007).	CLMS1	C1
114	Lead	LMS	Generate new ideas on alternatives to the current (Tidd & Bessant, 2011:16,17).	CLMS1	C1

Technology Innovation Leadership Capabilities based on Literature Review				TiIC1	TiIC2
134	Lead	VC	Encourage thinking in the direction of an emerging new future in line with the vision or strategic intent (Scharmer, 2007).	CLMS1	C1
21	Process	SH	Solicits energy to overcome organisational inertia and ways of retaining current status (Tidd & Bessant, 2013:109).	ATC7	C2
34	Process	VC	Provide context to set the right expectations so that ideas can flourish and mechanisms are used in the right way. This context to create is referred to as an "innovation architecture", the framework that leaders "…build within the organisation's mood and mindset that will give your creative and innovative ideas the traction they need to thrive". (Stefanovich, 2011: 100)	CLMS2	C2
88	Lead	SH	Build effective internal and external stakeholder relationships in which people "...think freely, come up with ideas for improvements or even dare to try something new" (Balmaekers, 2014, Harvey *et al.,* 2015).	CLMS2	C2
119	Lead	LMS	The leader provides a thinking environment in which physical and interpersonal factors allow freedom of expression in a supportive appreciative space following (Kline, 2008:35).	CLMS2	C2
124	Lead	LMS	Create a challenging yet emotionally safe environment for members to express curiosity and thinking beyond the boundaries of the current reality and tradition (Kanter, 1999; Skarzynski & Gibson, 2008; Swart, 2013; Gliddon, 2006; Coelux, 2015).	CLMS2	C2
29	Process	SH	Find out what is good and right about an idea, then improvise, build on or enhance it (Muller, 2013:92).	CLMS3	C3
41	Process	VC	Engage observers and voices that are not inhibited by current practices, players and vested interests (Scharmer, 2007)	CLMS3	C3
45	Process	VC	Encourage applied imagination towards the vision. Deep insight into problem or unmet need as foundation (Jaruzelski & Dehoff, 2010; Conway & Steward, 2009:300).	CLMS3	C3
48	Process	VC	Provoke and stretch knowledge worker curiosity, imagination and intellectual stimulation (Swart, 2013).	CLMS3	C3
67	Lead	Hi	The leader pushes boundaries on two levels. On the personal side, leaders who live abroad, work across different functions, and surround themselves with diverse team members continually expand their mindsets and creative problem solving abilities. On the strategic level, they continually push the limits of their teams, organisations, and partners (Harari, 1999).	CLMS3	C3
78	Lead	TC	Focus on discoveries with the potential to upset current market and business trajectories where a scientific field has emerged or reached an inflection point where it can solve, often in a new way, a practical problem of importance (Dugan & Gabriel, 2013:78).	CLMS3	C3
82	Lead	TC	Be competent to either acquire more advanced understanding of the technology innovation landscape or to at least ensure inclusion of these competencies in their innovation teams and the ability to guide the innovation effort towards new possibilities (Satell, 2015)	CLMS3	C3
90	Lead	SH	Recognise and embrace the power of cross-boundary collaboration (Hoque, 2015).	CLMS3	C3

Technology Innovation Leadership Capabilities based on Literature Review				TilC1	TilC2
108	Lead	LMS	Measure connections between behaviours, attitudes, innovation and creativity can help a technology innovation leader to bring about successful technology innovation (Stefanovich, 2011: 138)	CLMS3	C3
110	Lead	LMS	Provoke unconventional thinking approaches that bring about new perspectives needed for innovation (Skarzynski & Gibson, 2008:47).	CLMS3	C3
113	Lead	LMS	Value and utilise the diverse backgrounds and opinions of key members throughout feasibility research activities (Swart, 2013).	CLMS3	C3
115	Lead	LMS	Encourage applied imagination towards the vision. Deep insight into problem or unmet need as foundation (Jaruzelski & Dehoff, 2010)	CSH3	C3
117	Lead	LMS	Provoke and stretch knowledge worker curiosity, imagination and intellectual stimulation (Swart, 2013).	CLMS3	C3
122	Lead	LMS	Attract innovation team members with diverse and complementary profiles to contribute their ideas and perspectives to add value to technological innovation and values teamwork and members working (Hill *et al.,* 2014:52).	CLMS3	C3
140	Lead	VC	Assemble cross-functional teams that consist out of diverse team members with complementary skills and knowledge to commercialise our products, services or processes (Swart, 2013).	LMS3	C3
47	Process	VC	Create access to collective intellect of the firm and claim that their operations people are an integral part of strategic planning and development (Bracken, 2013).	CLMS4	C4
55	Process	IL	Stimulate external innovation	CLMS4	C4
56	Process	IL	Cultivate internally a “system mindset” that requires managerial attention, technical expertise and resources at the level of the overall system of platform.	CLMS2	C4
35	Process	VC	Bring together the vision, strategy and goals of the firm by conveying stories to employees and customers about what innovation means to the organisation and how employees and stakeholders can participate (Kelley, 2010:10-11)	CLMS5	C5
36	Process	VC	Generate and deliver innovative ideas for offerings, components and architectures	CLMS5	C5
43	Process	VC	Value and utilise the diverse backgrounds and opinions members throughout feasibility research activities (Swart, 2013).	CLMS5	C5
44	Process	VC	Generate new ideas on alternatives to the current (Tidd & Bessant, 2011:16,17)	CLMS5	C5
125	Lead	LMS	Implement mechanisms for ideas capturing for consideration (Swart, 2013)	CLMS5	C5
28	Process	SH	Using technical expertise and cognitive processing skills to evaluate ideas (Tidd & Bessant, 2013:113).	CLMS6	C6
66	Lead	Hi	The leader adopts a leapfrogging mindset – focusing on *creating or doing something radically new or different that* adds a completely new level of value (Innovation-point.com, 2014).	CLMS6	C6

Technology Innovation Leadership Capabilities based on Literature Review				TilC1	TilC2
121	Lead	LMS	Guide creativity in a way that produces answers linked to the context of problem solving, grounded in reality, and focused on productivity" (Gryskiewicz & Taylor, 2003:31).	CLMS6	C6
127	Lead	LMS	Apply holistic systemic thinking based on the **design** requirements (Gliddon, 2006).	CLMS6	C6
136	Lead	VC	Design for specific goals (Jaruzelski & Dehoff, 2010). Use information gathered from market research activities (Swart, 2013)	CLMS6	C6
32	Process	LMS	Making innovation a corporate-wide capability...to replace a company's old managerial DNA with new, innovation friendly practices and policies that enable and sustain new kinds of behaviours" (Kelley, 2010:xiv; Muller, 2013:140)	CLMS7	C7
33	Process	LMS	Craft conditions that guarantee participants freedom from criticism and encourage them to think of and express new ideas despite cultural conditioning risks involved (Nolan & Robinson, 2000).	CLMS7	C7
175	Lead	IL	Bring about increased levels of innovation through practices that expand member expertise or knowledge, creative thinking skills and intrinsic task motivation (Swart, 2013:22; Amabile, 1998:77; Amabile, 1998:80; Almonaitiene, 2013).	CLMS7	C7
46	Process	VC	Ensure evaluation and feedback on generated ideas (Tidd & Bessant, 2013: 113, Jaruzelski & Dehoff, 2010).	CLMS8	C8
49	Process	VC	Promote discussion and evaluation of different ideas amongst the members during the idea screening activities (Swart, 2013).	CLMS8	C8
109	Lead	LMS	Consider new possibilities beyond current core competencies in the innovation goal areas but that these be linked to a higher purpose that allows for what is called "quest-led" innovation that allows a leader to expand the business without over-reaching and stretching beyond their capabilities (Montague, 2015).	CLMS8	C8
126	Lead	LMS	Implement effective idea screening mechanisms based on clear criteria (Swart, 2013)	CLMS8	C8
128	Lead	LMS	Facilitate collective feasibility analysis of ideas to select those to be taken into value creation (Swart, 2013; Hauser *et al.*, 2008).	CLMS8	C8
129	Lead	LMS	Initiate exploration and exploitation through opening and closing behaviours (Rosing *et al.*, 2011).	CLMS8	C8
147	Lead	VR	Ensure that those who invested in the technology innovation can see the benefits from their investment (Tidd & Bessant, 2011:16; Tidd & Bessant, 2013:47).	CLMS8	C8
17	Process	SH	Ensure the development of a clear, well communicated and appropriately measured operating plan (Bracken, 2013).	CLMS9	C9
69	Lead	Hi	The leader conducts adaptive planning. Leading disruptive innovation requires managing high levels of uncertainty. The adaptive planning approach to leading implies that action leads to results, that leaders learns from them to modify assumptions and approaches accordingly and that such learning causes new insights that shape future actions that are even better calibrated to the needs of the market.	CLMS9	C9

Technology Innovation Leadership Capabilities based on Literature Review				TiIC1	TiIC2
70	Lead	Hi	Leaders recognise that surprises are inevitable during the innovation process and use these to make them agile and fast to capitalise on unforeseen events.	CLMS9	C9
97	Lead	SH	Recognise innovation involves moving targets and dynamic capability (Tidd & Bessant, 2011:16-17).	CLMS9	C9
139	Lead	VC	Avoid the use of highly detailed work plans and tight control during idea generation efforts as it will inhibit the creativity efforts of team members (Swart, 2013).	CLMS9	C9
57	Process	IL	Create external momentum	CLMS11	CB
132	Lead	VC	Influence the conversion of ideas into value, including prototype creation (Tidd & Bessant, 2013:124; Sloane, 2009a, Jaruzelski & Dehoff, 2010).	DVC1	D1
138	Lead	VC	Generate and apply feasibility criteria and processes to identify creations, prototypes, technology demonstrators or experimental designs with the highest of ability of realising value in line with the vision or strategic intent (Tidd & Bessant, 2011:16; Swart, 2013).	DVC1	D1
141	Lead	VC	Establish capacity to model/translate/simulate newly conceived possibilities into value demonstrators perceived to be valuable by targeted individuals.	DVC2	D2
142	Lead	VC	Apply systems thinking to identify, engage and integrate complementary skills to demonstrate value creation in tangible form (Coelux, 2015).	DVC2	D2
118	Lead	LMS	Promote discussion and evaluation of different ideas amongst the members during the idea screening activities (Swart, 2013)	DVC3	D3
157	Lead	VR	Effectively motivate team members during challenging periods in the idea generation process (Swart, 2013).	DVC3	D3
99	Lead	SH	Engage people, organisations, and partners in developing goals, executing plans, and achieving results. They build coalitions with key players, mobilise teams, and build momentum to get things done by communicating clearly and consistently, investing time and energy to engage.	DVC5	D5
100	Lead	SH	Develop a deep sense of consumer behaviour, consumers' needs and skills (to enable co-creation), and the capabilities of their large network of suppliers…".	DVC5	D5
101	Lead	SH	Build trust as basis for collaborative innovation: (Rosenfeld & Kolstoe, 2006; Bapat *et al.,* 2004).	DVC5	D5
38	Process	VC	Incubate "start-up-like" projects targeting the commercialisation of disruptive technologies and products.	DVC6	D6
87	Lead	TC	IL shows understanding of technology elements and configurations working together as system to achieve their goal (Bausch, 2013).	DVC8	D8
105	Lead	SH	Influence collective thinking of decision-makers through personal credibility in the technology innovation domain (CSIR, 2010).	DVC8	D8
116	Lead	LMS	Ensure evaluation and feedback on generated ideas (Tidd & Bessant, 2013: 113, Jaruzelski & Dehoff, 2010).	DVC8	D8

Technology Innovation Leadership Capabilities based on Literature Review				TilC1	TilC2
131	Lead	VC	Integrate other disciplines in the process technology innovation aimed at creating value (Bronet *et al.,* 2003:183)	DVC9	D9
137	Lead	VC	Plan to provide sufficient information, time and resources for introduction and adoption of new technology (Prahalad & Krishnan, 2008:2; Swart, 2013).	EVR1	E1
149	Lead	VR	Formulate marketing strategies that effectively cater to the unique needs of the target market during the commercialisation (Swart, 2013).	EVR1	E1
143	Lead	VC	Facilitate development of a business model for transfer and uptake of the technology into the mainstream (Smith, 2010)	EVR2	E2
148	Lead	VR	Network effectively in order to provide team members with access to experts during the commercialisation process (Swart, 2013).	EVR2	E2
159	Lead	VR	Create a conducive environment for implementing new technology that will replace existing technologies and practices (Rosenfeld & Kolstoe, 2006, Moore, 2014).	EVR2	E2
160	Lead	VR	Establish the co-creation capabilities required for effective introduction of technology innovations (Petersen, 2015).	EVR2	E2
161	Lead	VR	Seek to establish support in the market place for a technology configuration that other providers have to eventually adhere to if they wish to command a significant market following (Smith, 2010).	EVR2	E2
145	Lead	VR	Use business model to align stakeholders for implementation (Petersen, 2015) and commercialisation (Jaruzelski & Dehoff, 2010).	EVR3	E3
146	Lead	VR	Diffusion/adoption: Make sure the new technology is presented as attractive enough for people to adopt the new (Tidd & Bessant, 2011:16);	EVR3	E3
151	Lead	VR	Negotiate effectively with suppliers to commercialise products, services and/or processes successfully into the market (Swart, 2013).	EVR3	E3
52	Process	VR	Provide stakeholder education to bring about understanding and trust while reducing fear, uncertainty and doubt that often stands in the way of diffusion of newly generated technologies (Stanford Graduate School of Business, 2013; Moore, 2014).	EVR4	E4
96	Lead	SH	Ensure the development of a clear, well communicated and appropriately measured operating plan (Bracken, 2013).	EVR4	E4
144	Lead	VR	Migrate from newly created value in the form of prototypes, technology demonstrators or experimental designs to concretise operationalising new technology (Tidd & Bessant, 2011:16).	EVR4	E4
150	Lead	VR	Value the opinions of potential customers/clients during the screening of new ideas (Swart, 2013).	EVR4	E4
152	Lead	VR	Maintain on-going monitoring of the environment and technology to capitalise on new opportunities (Swart, 2013)	EVR4	E4
153	Lead	VR	Value the ideas, suggestions and critique of prospective customers/clients during feasibility research (Swart, 2013).	EVR4	E4

Technology Innovation Leadership Capabilities based on Literature Review				TiIC1	TiIC2
89	Lead	SH	Maintain relationship between the firm and the consumer, where feedback on usage and proposed better utilisation or performance are key components of how the firm interacts with customers. The dynamic reaBtime reconfiguration of resources will become more important as visibility of the “complex web of product and information flows” increase (Prahalad & Krishnan, 2008:89).	EVR5	E5
155	Lead	VR	Effectively utilise the positive and negative feedback obtained during the feasibility phase to refine and adjust the feasibility research process accordingly (Swart, 2013).	EVR5	E5
156	Lead	VR	Handle the criticism of potential customers and clients during the feasibility phase in a constructive manner. Know that the cultural differences of our customers/clients will influence their decision whether or not to adopt our products, services or processes during commercialisation (Swart, 2013).	EVR5	E5
158	Lead	VR	Develop a guiding technology deployment and adoption framework for migrating from value creation to realisation of value	EVR5	E5
51	Process	VR	Act as “orchestrator” to play an important role in decreasing bottlenecks in value chains	EVR6	E6
130	Lead	LMS	Alternate between influencing exploration and exploitation as fundamental activities in any innovation (Rosing *et al.,* 2011)	EVR7	E7
54	Process	IL	Manage platform evolution	EVR11	EB
59	Process	IL	Inspire, energise and intellectually stimulate others in pursuit of a shared technology innovation vision (Bass, 1990:19; Elkins & Keller, 2003; Bry, 2015).	EVR11	EB
53	Process	IL	Balance multiple roles	FIL1	F1
60	Process	PG	Demonstrate behaviours that can be emulated by peer leadership to facilitate collaborative, positive team interaction and close satisfying relationships among team members (House, 1996:341).	FIL1	F1
62	Process	DJ	Lead by example as role-model by consistently displaying curiosity, initiative, idea generation, exploring value creation opportunities, sense of urgency, tenacity, trustworthy, humility and learning (De Jong & Den Hartog, 2007; Almonaitiene, 2013; Conway & Steward, 2009).	FIL1	F1
165	Lead	IL	Serve as innovation role-model by being an example of innovative behaviour, exploring opportunities, generating ideas, enthusiastic championing and putting efforts into technology innovation (De Jong & Den Hartog, 2007; Almonaitiene, 2013; Conway & Steward, 2009).	FIL1	F1
166	Lead	IL	Lead by example as role-model by consistently displaying curiosity, initiative, idea generation, exploring value creation opportunities, sense of urgency, tenacity, trustworthy, humility and learning (De Jong & Den Hartog, 2007; Almonaitiene, 2013; Conway & Steward, 2009).	FIL1	F1
39	Process	VC	Customise the innovation vision, portfolio and other innovation aspects for the particular context and maturity levels (Kelley, 2010:30).	ATC7	F2
74	Lead	TC	Identify key opportunity from forest of possibilities (which and	ATC7	F2

Technology Innovation Leadership Capabilities based on Literature Review				TiIC1	TiIC2
			why) (Tidd & Bessant, 2011:16)		
75	Lead	TC	Strategic choice on which opportunities to include in time planning horizon (Tidd & Bessant, 2013:47).	ATC7	F2
31	Process	SH	Select the innovation vector upon which the firm will develop its sustainable competitive advantage and declare innovation as a critical element of the business strategy, lead innovation as a continuous process that includes multiple sub-processes with processes selected for their relevance to the firm's strategy, ensure that innovation follows a disciplined and scientific approach and access collective knowledge, capability, and resource embodied within the broad horizon networks of innovation participants (Muller, 2013:74).	FIL2	F2
64	Lead	Xu	Approach innovation as a long-term competence-based management philosophy for achieving sustainable competitive advantage involving all people at every aspect and organisational level at all times and across all spaces (Xu *et al.,* 2007:16).	FIL2	F2
102	Lead	SH	Increase member self-efficacy and collective efficacy through expressing positive evaluations, communicating higher performance expectations of members, showing confidence in members' ability to meet such expectations, and emphasising the individual's ties to the collective (Shamir *et al.,* 1993:581-584).	FIL2	F2
162	Lead	IL	Transformational leadership: Inspire, energise and intellectually stimulate others in pursuit of a shared technology innovation vision (Bass, 1990: 19; Elkins & Keller, 2003; Bry, 2015).	FIL2	F2
167	Lead	IL	Provide vision by communicating an explicit vision on the role and preferred types of innovation, providing strategic intent for future activities in support of organisational purpose (De Jong & Den Hartog, 2007; Tidd & Bessant, 2013:106; Stefanovich, 2011; Elkins & Keller, 2003; Baker, 2003; Sloane, 2009a; Bracken, 2013; Shamir *et al.,* 1993:585; Börjesson *et al.,* 2014:136; Gill, 2011).	FIL2	F2
168	Lead	IL	Develop and communicate an inspirational innovation vision that inspires those involved to work towards the desired future innovation outcome (Baumgartner, 2010; Mashelkar, 2010; Swart, 2013, Muller, 2013; Elkins & Keller, 2003; Gliddon, 2006; Von Stamm, 2009)	FIL2	F2
176	Lead	IL	Approach innovation as a long-term competence-based management philosophy for achieving sustainable competitive advantage involving all people at every aspect and organisa-tional level at all times and across all spaces (Xu *et al.,* 2007:16).	FIL2	F2
179	Lead	IL	Build a community with a sense of shared purpose (reason for existence), values (what is agreed as important and rules of engagement) how to interact with each other and think about problems (Hill *et al.,* 2014:191).	FIL2	F2
123	Lead	LMS	Provide learning opportunities for members to master or refresh their thinking skills for their participation in the technology innovation process (Gliddon, 2006; Swart, 2013).	FIL3	F3
163	Lead	IL	Path –Goal: Demonstrate behaviours that can be emulated by peer leadership to facilitate collaborative, positive team	FIL3	F3

Technology Innovation Leadership Capabilities based on Literature Review				TiIC1	TiIC2
			interaction and close satisfying relationships among team members (House, 1996:341).		
164	Lead	IL	Leader-member exchange: Develop high-quality leader-member relationships with members based commitment, trust, mutual respect and liking (Rosing *et al.,* 2011:964; Elkins & Keller, 2003:587; Anderson *et al.,* 2014:1322; Swart, 2013).	FIL3	F3
169	Lead	IL	Engage with people before initiating changes that may affect them, creating trust and emotional safety for people to take initiative and incorporating their ideas and suggestions in decisions (De Jong & Den Hartog, 2007; Tidd & Bessant, 2011:504; Hammett, 2007; Elkins & Keller, 2003; *Bapat et al.,* 2004:23).	FIL3	F3
133	Lead	VC	Engage and empower team members by providing them with freedom and autonomy for both initiation and persistence of subordinates' task behaviour and refer to deliver desired innovate results (Conger & Kanungo, 1988:474; Bandura, 1986; Swart, 2013).	FIL4	F4
170	Lead	IL	Equip members with sufficient authority and freedom to act to determine relatively independently and confidently how to achieve innovation goals where they can use their strengths to address challenges (De Jong & Den Hartog, 2007; Almonaitiene, 2013; Hammett, 2007; Krause, 2004; Elkins & Keller, 2003; Bapat *et al.,* 2004:28).	FIL4	F4
61	Process	LMX	Develop high-quality leader-member relationships with members based commitment, trust, mutual respect and liking (Rosing *et al.,* 2011:964; Elkins & Keller, 2003:587; Anderson *et al.,* 2014:1322; Swart, 2013).	FIL5	F5
63	Process	AM	☝ Bring about increased levels of innovation through practices that expand member expertise or knowledge, creative thinking skills and intrinsic task motivation (Swart, 2013:22; Amabile, 1998:77; Amabile, 1998:80; Almonaitiene, 2013).	FIL5	F5
120	Lead	LMS	Provide challenge in the work environment by matching people with assignments that play to their skills and expertise and motivation (Almonaitiene, 2013:81).	FIL5	F5
171	Lead	IL	Provide personal and organisation commitment and support for innovation by acting friendly to innovators, being patient and helpful, listening, looking out for members' interest if problems arise, organisational protection so that they can focus on innovation that matters while learning from mistakes (De Jong & Den Hartog, 2007; Von Stamm, 2009:465; Hogan & Coote, 2014:1629; Bapat *et al.,* 2004:22; Börjesson *et al.,* 2014; Krause, 2004; Goffee & Jones, 2007:74; Almonaitiene, 2013:83; Le Storti, 2003:59; Almonaitiene, 2013:84; Sloane, 2013).	FIL5	F5
178	Lead	IL	Create an environment where people are willing to do the hard work of innovation with its inherent paradoxes and stresses (Hill *et al.,* 2014:191)	FIL5	F5
172	Lead	IL	Recognise and show appreciation for innovative results through communication and information on progress (De Jong & Den Hartog, 2007; Tidd & Bessant, 2013:106; Bry, 2015).	FIL6	F6

Technology Innovation Leadership Capabilities based on Literature Review				TilC1	TilC2
173	Lead	IL	Make effective use of recognition and rewards to show appreciation for innovative contributions of the team (Gliddon, 2006; De Jong & Den Hartog, 2007).	FIL6	F6
65	Lead	GI	Facilitate forward and backward flows of influences, activities and information between individual and group creativity across innovation process stages (Gliddon, 2006).	FIL7	F7
77	Lead	TC	Learn to depend on the intuition as well as the evidence of the moment to reach decisions quickly with minimal information Cartwright, 2004:27).	FIL7	F7
154	Lead	VR	Consider the mistakes and failures of team members during the commercialisation process as invaluable learning experiences (Swart, 2013).	FIL7	F7
68	Lead	Hi	The leader integrates data and intuition. Hard data is needed for making important decisions. In times of disruption, however, robust data rarely exist. Leaders must use information they can obtain from any and all sources inside and outside the organisation – but then be comfortable using their gut for the rest.	FIL9	F9
135	Lead	VC	Create structures and conditions for successful management of the innovation process (Tidd & Bessant, 2011:16,17).	FIL11	FB
174	Lead	IL	Monitor innovation progress through pursuit of effectiveness and efficiency, attending to people issues to allow self-driven individuals to meet their challenges, stressing tried and tested routines (De Jong & Den Hartog, 2007; Bry, 2015).	FIL11	FB
177	Lead	IL	Facilitate forward and backward flows of influences, activities and information between individual and group creativity across innovation process stages (Gliddon, 2006).	FIL11	FB

APPENDIX D:

TRIANGULATION-DERIVED TECHNOLOGY INNOVATION LEADER CAPABILITIES AND BEHAVIOURS

Capability cluster 1: Being connected with the evolving technology innovation landscape	
ATC1	The technology innovation leader builds rich and varied ways or **channels** to stay informed of new knowledge and technology innovations to inform unit technological innovation decisions.
ATC2	The technology innovation leader maintains effective networks to **access contents sources** of expertise and of the latest science and technology developments that may influence the firm's technological innovation.
ATC3	The technology innovation leader builds absorptive surveillance capacity in the unit to collectively track and **process** early signals of emerging changes in the strategic, operational and technological landscape in which the firm operates.
ATC4	The technology innovation leader maintains on-going learning (technical and business) to enhance **own credibility** as thought leader.
ATC5	The technology innovation leader applies a wider perspective, intuitively thinking of possibilities beyond current comfort zones in **anticipation** of future technological innovation.
ATC6	The technology innovation leader **considers** innovation opportunities related to the strategic intent of the unit for future technological innovation.
ATC7	The technology innovation leader selects innovation areas with the potential to strengthen the strategic future value of their innovation pipeline and **portfolio.**
ATC8	The technology innovation leader detects the **early signals** of emerging opportunities, challenges, problems, players and landscape dynamics as inputs into technological innovation.
ATC9	The technology innovation leader **explores** the larger PESTLE (political, economic, social, technological, legal and environmental) environment daily for technology innovation possibilities.
ATC10	The technology innovation leader **models** (e.g. business models and technology road maps) alternative futures based on the influence of anticipated technology landscape changes on the competitiveness of the unit.
Capability cluster 2: Mobilising stakeholder alignment, support and participation	
BSH1	The technology innovation leader identifies and interacts with stakeholders (opinion shapers and decision-makers), building personal **trust based relationships** with individuals that may influence or contribute to technological innovation of the unit.
BSH2	The technology innovation leader **understands** the needs, political agendas, roles and expectations of stakeholders in relation to our technological innovation.
BSH3	The technology innovation leader is effective in obtaining **support** for the envisaged technological innovation area by understanding and relating envisaged benefits for the respective stakeholders.
BSH4	The technology innovation leader secures **resources** that are required for the envisaged technological innovation of the unit, including interaction time of decision-makers.
BSH5	The technology innovation leader aligns stakeholder requirements through beneficial or **compelling images** of technology futures that leave stakeholders that instil a sense of urgency and excitement with stakeholders in anticipation of the envisaged technological innovation.
BSH6	The technology innovation leader attracts **enthusiastic competent innovation talent** to consider as team members with complementary profiles and ability to add value to our technological innovation.

BSH7	The technology innovation leader avoids, anticipates, **detects and resolves tensions or conflicts** between entities and conflicts of interests pertaining to the technological innovation envisaged.
BSH8	The technology innovation leader establishes effective **governance** mechanisms through which stakeholders stay informed and influences the development during the envisaged technological innovation.
BSH9	The technology innovation leader develops **innovation design parameters** based on requirements and **motive**s of decision-makers and opinion leaders.
Capability cluster 3: Liberating mindsets	
CLMS1	The technology innovation leader appoints technology innovation **team members** with diverse experiences, backgrounds, disciplines and competencies needed to realise the technological innovation vision to be pursued.
CLMS2	The technology innovation leader creates an innovation **conducive environment through purpose-directed, values based rules of engagement** for team interactions that optimise member contributions through exchange and discussion of ideas and sensitive information without having to fear victimisation.
CLMS3	The technology innovation leader stimulates and **provokes** unconventional ideas and thinking as building blocks towards the achievement of the technology innovation vision.
CLMS4	The technology innovation leader implements **effective idea generation and sharing activities** (e.g. brainstorming sessions, focus group discussions, strategy sessions, etc.) internally and externally.
CLMS5	The technology innovation leader establishes **effective idea capturing mechanisms** allowing people to effortlessly submit ideas they generated (e.g. suggestion box, including the forums, etc.).
CLMS6	The technology innovation leader facilitates **integrative technology solutions** through systems and whole brain thinking by the team in assessing ideas in terms of their contribution towards the technology innovation vision and goals.
CLMS7	The technology innovation leader fosters constructive positive **team dynamics and resolves people tensions** without delay so that the team can channel their creative energies towards the innovation vision.
CLMS8	The technology innovation leader establishes routines and **capabilities** in the team to determine the **feasibility** of newly generated ideas that have the best chance of contributing to the attainment of the technological innovation being envisaged.
CLMS9	The technology innovation leader solicits technology innovation-based value propositions for stakeholder context rather than highly **detailed work plans and tight control** during ideation as it will inhibit creativity efforts of team members.
CLMS10	The technology innovation leader ensures that technology design parameters are **contextualised** (problems, challenges, opportunities, requirements) to inform thinking processes.
Capability cluster 4: Facilitation of value creation	
DVC1	The technology innovation leader establishes effective practices (processes and guidelines) for converting promising concepts into **concrete manifestations** such as prototypes, technology demonstrators, and experimental designs that convey what the technology can do.
DVC2	The technology innovation leader re-constitutes the technology innovation team if needed to ensure that required capabilities (like skills, equipment and infrastructure) are available testing and refining and producing **technology innovations perceived to be valuable** by targeted stakeholders.
DVC3	The technology innovation leader establishes effective individual and collective team capabilities to solicit and process **stakeholder feedback** that may be used to enhance future demand for the invention.

DVC4	The technology innovation leader acknowledges the potential destruction or disruption of current technologies that may come with new technological innovation and crafts effective **migration pathways** to avoid unintended negative consequence.
DVC5	The technology innovation leader facilitates **simulation and exploration** of augmented technology configurations to consider customisation for different applications and stakeholder segments.
DVC6	The technology innovation leader facilitates effective decision-making by all involved to reach informed **stop or go decision**s based on agreed and shared criteria that combine disparate or even opposing ideas.
DVC7	The technology innovation leader establishes effective mechanisms to identify and protect new **intellectual property** flowing from team deliberations.
DVC8	The technology innovation leader conducts rapid experimentation, value and progress assessments to enhance **readiness** of the new technology for introduction to and adoption by targeted individuals and groups.
DVC9	The technology innovation leader networks effectively with members from other departments and business units to create cross-functional **collaborative commercialisation teams** to ensure adoption of the new technology (alone or as products, services or processes).
DVC10	The technology innovation leader establishes **effective collaborative innovation** through effective negotiation with collaborators and partners to commercialise our products, services and/or processes successfully into the market or value chain.
Capability cluster 5: Facilitation of value realisation	
EVR1	The technology innovation leader facilitates the development of **innovative market and marketing strategies** in pre-launch mode in which critical success factors for market entry are identified and integrated.
EVR2	The technology innovation leader facilitates **co-creation of whole product solutions** for "crossing the chasm" during the technology introduction and adoption phases.
EVR3	The technology innovation leader uses networks, client demands, regulatory forces and success stories to achieve **market allegiance** for the new technology to become the standard (also called dominant design) for specifiers and regulators of technology solutions (stakeholders).
EVR4	The technology innovation leader provides educational support on new technologies (to address fear uncertainty and doubt) for smooth implementation and **adoption** of technological innovations in support of sales and marketing activities of the unit.
EVR5	The technology innovation leader maintains **agile responsive capacity** in the innovation team to monitor and respond to anticipated and un-anticipated implementation challenges (technology and market).
EVR6	The technology innovation establishes an **innovation eco-system** that keeps the innovation members and stakeholders networked for on-going learning and refinement of technology innovation practices.
EVR7	The technology innovation leader facilitates **effective transfer of the new technology** in line with the commercialisation business model established.
EVR8	The technology innovation leader monitors and manages technology **deployment** levels in line with demand levels and production capabilities.
EVR9	The technology innovation leader explores technology **platform expansion/scaling** opportunities and applications to enhance return on investments. Made and maintains symbiotic relationships with all involved in supply chain delivery.
EVR10	The technology innovation leader engages on-going technology **innovation support** to broaden understanding of potential future technological innovation opportunities, such as R&D and innovation communities.

Capability cluster 6 : Integration through leadership	
FIL1	The technology innovation leader leads by example as **role-model** in exploring opportunities, generating ideas, learning from experience and determining the feasibility of ideas for value creation and value realisation with strong emphasis throughout on the interrelatedness of all innovation activities.
FIL2	The technology innovation leader develops and communicates an **inspirational and intellectually challenging innovation vision** and strategic purpose to scope the preferred types of innovation and direction for the innovation team. This may include problems, challenges or opportunities.
FIL3	The technology innovation leader **engages** people before initiating changes that may affect them, incorporating their ideas and suggestions in innovation processes and decisions.
FIL4	The technology innovation leader **empowers** members by establishing shared ownership and allowing members sufficient freedom and autonomy to determine by themselves or with others how to meet their innovation objectives. This includes being allowed to make mistakes and learn from them.
FIL5	The technology innovation leader **supports and motivates** members by giving them space to do what they value, both in times of passion and pain. This includes acting friendly, showing respect, being patient and helpful, listening, and looking out for someone's interests if problems arise.
FIL6	The technology innovation leader shows **appreciation** for innovative performances of those involved and makes effective use of **rewards** to promote the creative efforts of team members during innovation.
FIL7	The technology innovation leader oversees on-going innovation progress and **provides constructive timely feedback** to team members during innovation to learn from success and failures during innovation.
FIL8	The technology innovation leader radiates positive **innovation energy** rooted in positive attitude, group dynamics and organisational support for vision aligned technological innovation.
FIL9	The technology innovation leader **facilitates systemic integration** of technology innovation through alignment of all elements (technical, human, business).
FIL10	The technology innovation leader provides an overarching **innovation architecture** (design, elements, structure and flow) that allows collaborative technology innovation.
Fil 11	The technology innovation leader solicits intense **near-obsession-like levels of ownership** for generating solutions to innovation challenges opportunities or problems.

APPENDIX E:

TRIANGULATED TECHNOLOGY INNOVATION PROCESS DIMENSIONS

Technology innovation process coding applied to triangulated sources		
Source	**Research data**	**Codes linked to sources**
Theory	Generic process	Kn,Dev,Des,ME,Eng,Pilot, M&S, Del,Com
Theory	Technology push	Kn,Dev,Des,ME,Eng,Pilot, M&S
Theory	Demand pull	Dev, Prod, M&S, Ne
Theory	Coupling	Id, Kn,Dev, Des, ME, Eng, Pilot, Prod, M&S, Del, Com, Ne
Theory	Integrated process	Kn, Dev, ME, Eng, Pilot, Prod, M&S, Sup, Del, Com, Ne
Theory	Open innovation	Ext, Dev, Com
Theory	Fugle process	Id, Fe, Fu, Por, Eng, Expl
Theory	Network spiral	Ext, Kn, Dev, Fu, M&S
Theory	Stage-gate	Id, Con, Dev, Pilot, M&S
Theory	Presencing	Se, Cr, Pilot
Literature I	Process model constraints - avoid lock in	Lo
Literature I	Systemic efficiency - Contribute to process and systems efficiency and innovation portfolio.	Effy
Literature I	Complexity - allow switching between explore/exploit	Sw
Literature I	Compliance - idea generation and implementation	Cy
Literature I	Creation through knowledge exchange and flow	Kn
Literature I	Iterative thinking in innovation process	IT
Literature I	Avoid negative effects of task partitioning	TP
Literature I	Process as agility - need for fast flexible process to accommodate change	AFF, Pu, ACT, Sim
Experts	EIEohML: ..there has definitely been a shift, from an industrial to a knowledge utilisation paradigm. Let me take you through our journey. We started in 1948.	Kn, Dev
Experts	EITelkBF: it sometimes becomes very painful because some companies are very process driven and I think sometimes innovation is actually stopped by a very process driven company. You can't be fast and reactive as far as that is concerned	LMS, Sw
Experts	EICsirJlR: the innovation process in my view would be, and I've identified this in working with leaders driving technological innovation from a technology point of view as well as a business point of view... I saw with many of these that the formal linear process is just there to ensure that guidance and order is there to direct your thinking and planning and execution. It is not necessarily linear and sequential	Lo, IT, Pu, ACT

Experts	EICsirJlR: the technology innovation leader has to come back and review overall progress not just in one box at a time but several blocks to ensure progress. I think it's important to do that on a regular basis to make sure that you are on track and that you are addressing the right issues.	Sw, ACT, Sim, IL, BOPF
Experts	EICsirJlR: You learn from the various involvements in the various phases of the process and that informs the decisions on the way forward. This contributes to the main innovation phase where you are. So in my view no point I think is great to have that as a model the kind of standard approach which is important for overall guidance and direction and to check where you are but not necessarily to follow it step-by-step phase by phase	Pu, BOPF
Experts	EITelkSL: so I think there was a linear process component in the lab once, they had a certain amount of rigour but I think in terms of setting it up for innovation it was not linear, it was more about setting the people in the system up to be successful which is a bit different.	CC, Sw, Pu, IL
Experts	EIDaVRM: what we are seeing now is a much less formal process. Let me give you an example. In technology top 100 we are picking up companies, as I was telling people last night, like this one company who turns around and says on Friday morning there is no work formally in the organisation. You either sit with your colleagues and you talk to them about ideas or in fact you sit on your own but we expect you by lunchtime	Sim, IL, BOPF
Experts	EIDaVRM: we are very sceptical about some of these processes. Look, you cannot deny that some of these stage gate processes are important and therefore when you talk about the process I still think that you have to have stage gates where you sit down and you talk through the stages	Id, Con, Dev, Pilot, M&S, TP, Pu, Sim, IL
Experts	EIDaVRM: ...when these companies go through stage gate they say look, here is (innovator), he has a brilliant idea to develop a model for technology leadership and he has almost set himself a roadmap and on the strength of finishing phase 1 where he has gathered all the data and when you review this thing you say it is not panning out the way I wanted it to and then what they say is what are the other options that might come out of this thing. In other words, they would go and provide a formal process of achieving some end goal and then say hey you know what, we've had this interesting breakthrough in events which we never anticipated.	Id, Con, Dev, Pilot, M&S, TP, Pu, Sim, IL
Experts	EICsirJlR: He said it so bright that you don't need a light. So, David King said to his wife I think this guy is drunk. Anyway, he said I'll meet you at 9:30 tonight because it gets dark quite late in summer and sure enough they walked inside the laboratory and in this was glowing. The intention never was to develop such a chemical but out of that developed this multi-million Rand emergency lighting system which is just a chemical.	Cr, IT
Experts	EIDaVRM: what you are seeing is acknowledgement that technology innovation exposes the company to huge amounts of risk, you can't deny you can't also have it at the same time as a linear process. It is in fact very non-linear. So, we are saying that the process is more around engaging people, more around creating an environment which is really conducive to alternative thinking and very conducive towards listening and exploring and things like that, you see this becoming more and more, like contagious.	Cr, IT, IL, BOPF

Experts	EIDaVRM: one of the executives who recently retired from Altron said "you know we're good but we could be so much better if in fact we were to look at the more relaxed approach to leading innovation".	Pu, Sim
Experts	EIDaVRM: So, I think when you look at the process there is a lot of informality...They got this guy on board who became one of the leaders in the field... But he can talk to anybody at any level, and talk to you, the head of a company. To him he is not worried about this process thing and he talks to people at all levels.	Sw, AFF, Sim, IL, BOPF
Experts	EIDaVRM: I think also that in these competencies is this issue around the market push and market pull. When you look at Sony who in its heyday was definitely working on market push. Sony never did any market survey. They would rather say we have a hell of a good idea, and turn around and say how do we actually persuade...	Sw, AFF, Sim, IL
Experts	EICokGW: what was needed by the company at the beginning of the journey and still is needed is some nomenclature and processes that support the acceleration of innovation, the understanding of it and the activation of it by organisation.	AFF, Sim
Experts	EICokGW: When I have for instance the big town hall meeting with the technical community I would always say stay eternally curious. Stay curious. We all have a job to do, we have performance objectives to meet but on top of this stay curious whether it's related to your job or not even related to your job... If you are curious then you connect, and if you connect you can collaborate, and the more you collaborate the more you will collect the benefit.	Id, Kn, Cr, Pu
Experts	EISasTD: I don't think the processes themselves will result in such innovation, but it creates an enabling environment in which the innovation can take place.	Pilot, Pu, IL
Experts	EISasTD: People tend to say you need anthropy 4:29 to achieve innovation, which has some merit. Then you come to environments like (confidential) where you have a strategy that is very crisp rather than pervasive, and then you need to respond to, and you then need to have an innovation process that ensures that everything you do contributes towards the strategy. So there is a lot of formality and there is a lot of structure. One needs to be careful about how you talk on innovation in these two environments.	Effy, Sw, Cy, Pu
Experts	EISasTD: Having the process should at least allow to plan for what you want to achieve, because it is by following the plan you are able to take the ideas all the way to the point where you can make an informed decision, whether you continue with it or you stop it or you commercialise. You can hide behind a lack of structure which then becomes an excuse for not planning properly and being held accountable for achieving the planned results...But the structure and process need to be nuances for the specific environment. And I think they are differences between the academic environment, the environment of the science councils and the environment of the private sector. You may not be able to same approach but nonetheless need a process to apply. Another very important process for me is to have an integrative innovation model.	SHA, Com, Sw, TP, IL, BOPF

Cases	Steve Jobs biographic film	TC, SHA, LMS, Cr, Pilot, IL
Cases	President J.F. Kennedy	SHA, Con, Fe, Pilot, IL
Cases	CSIR technology innovation cases	Se, TC, Id, SHA, LMS, Con, Ds, CC
Cases	Thirty science derived cases from South Africa (Wild, 2015)	SHA, LMS
Practitioner workshop	Leader competencies grouped into capability clusters	TC, IL
Literature II	Organisational settings	Se, SHA, Pu, IL
Literature II	Exponential knowledge production - traditional R&D under pressure	Se, TC, Id, LMS,
Literature II	Creative combinations of different disciplines	CC
Literature II	Front end considerations have biggest impact	TC,
Literature II	T-shaped professionals	LMS, CC, TP, IL, BOPF
Literature II	Creative behaviour of people	Cr, CC
Literature II	Mobile technologies introduce new rules	Se, TC, LMS
Literature II	Innovation process and strategic thinking	Pu, BOPF
Literature II	Need for new thinking and radical theories from new insights	LMS
Literature II	Integration by leader	TC, Id, SH, LMS, Ku, Por, Sw, IT, Pu, IL

APPENDIX F:
ILQ BEHAVIOURS

Table F.1 below shows the 68 competency behaviours developed by Swart (2013), each of which was considered as sources of input for the identification of technology innovation leadership competencies that are deemed to be required for successful technological innovation, which is the core focus of this study. For control purposes, the left column in Table F.1 below comes from the item numbers allocated by Swart for each of his 68 innovation leader behaviours or competences. An asterisk next to a listed behaviour indicates that the statement had been incorporated into the pre-expert review version of the technology innovation leadership competence profile of leadership behaviours deemed to be required for successful technological innovation.

Table F.1: Innovation leadership (IL) behaviours identified by Swart

2	IL successfully implements idea generation activities (e.g. brainstorming sessions, focus group discussions, strategy sessions, etc.).*
17	IL successfully implements practices and procedures allowing team members effortlessly submit ideas they generated (e.g. suggestion box, including the forums, etc.)*
21	IL successfully implements the necessary practices and/or procedures for advocating and screening new ideas.
34	IL effectively conducts feasibility research to determine the extent to which ideas can be implemented and commercialised successfully into the market.
1	IL effectively formulates an innovation vision for our team at the start of the idea generation process.
10	IL successfully mentors and/or coaches team members during the process of idea generation.
42	IL effectively mentors and/or coaches team members during his ability research practices/procedures
46	IL role-models creative behaviours during feasibility research which promotes a learning organisation culture in our organisation.*
18	IL avoids the use of highly detailed work plans and tight control during idea generation efforts as it will inhibit creativity efforts of team members.*
20	IL empowers team members effectively during the idea generation process by providing them with sufficient freedom and autonomy.*
31	IL provides team members with the necessary freedom and autonomy to ensure that everyone feels empowered and participates the idea screening process.*
35	IL successfully trains and/or educates team members how to conduct feasibility research on their own.
39	IL effectively empowers team members by providing them with the freedom and autonomy to engage in feasibility research activities.*
12	IL effectively motivates team members during challenging periods in the idea generation process.*
13	IL managers to engage team members in idea generation activities without hesitation by way of his/her social/interpersonal skills.
30	IL effectively promotes the discussion and evaluation of different ideas amongst the members during idea screening activities.

9	IL makes effective use of rewards to promote the creative efforts of team members during an idea generation.*
19	IL successfully acknowledges the creative efforts and contributions of team members during the generation process.*
29	IL provides constructive and timely feedback to team members whose ideas have been screened*
11	This leader avoids criticising the idea generation efforts of team members prematurely as it will decrease the creativity efforts of team members.*
36	IL considers the mistakes and failures of team members during the feasibility phase as invaluable learning experiences.*
41	IL informs team members that most ideas will fail during feasibility research and regardless of the outcomes it is considered an invaluable learning experience.*
68	IL considers the mistakes and failures of team members during the commercialisation process as invaluable learning experiences.*
48	IL values and utilises the diverse backgrounds and opinions of key members throughout feasibility research activities.*
54	IL assembles cross-functional teams that consist out of diverse team members with complementary skills and knowledge to commercialise our products, services or processes.
24	IL networks effectively with idea advocates from other business units/teams/departments to screen new ideas.
53	IL networks effectively with members from other departments and business units to create cross-functional teams that will commercialise our products, services or processes.*
59	IL networks effectively in order to provide team members with access to experts during the commercialisation process.*
6	IL successfully persuades members of management to obtain the time/resources necessary for idea generation to occur.*
23	IL often acts as an idea advocate and persuades management of the potential value of ideas submitted by team members.
25	IL effectively persuades members of management to obtain the necessary resources and support for establishing practices and/or procedures to screen the ideas of team members.*
45	IL effectively persuades members of management to provide the necessary time/resources required for feasibility research to occur.*
55	IL effectively persuades members of management to provide the necessary time/resources required for commercialisation to occur.*
56	IL effectively negotiates with suppliers to commercialise our products, services and/or processes successfully into the market.*
5	IL effectively communicates the innovation vision of our team to team members.*
50	IL communicates the commercialisation strategy to team members successfully.*
63	IL clearly communicates the criteria (success indicators) that are made use of to evaluate how successful team members commercialised our products, services or processes.*
8	IL presents idea generation activities in a way that is intellectually stimulating for team members.*
14	IL makes valuable contributions to idea generation activities because of his/her technical expertise.
22	IL possesses sufficient technical expertise to know which ideas should be advocated and/or supported.
38	IL has the technical expertise to successfully determine the commercial and technical feasibility with which ideas can be introduced into the market.
58	IL has the technical expertise to calculate and interpret profitability metrics (e.g. return-on-investment, etc.) during the commercialisation process successfully.

64	IL possesses sufficient technical expertise to analyse and interpret the results obtained from market research studies successfully during commercialisation.
28	IL objectively screens the ideas of the members during idea screening.
3	IL is curious and frequently challenges the status quo during idea generation activities.*
15	IL successfully solves problems that arise throughout the idea generation process in a creative fashion.
43	IL successfully documents and records the information and results obtained from feasibility research activities.
60	IL successfully gathers information throughout the commercialisation process by way of market research (e.g. market survey, interviews, etc).
49	IL effectively formulates a commercialisation strategy for our team's products, services or processes.
7	IL makes effective use of goal setting to enhance creative efforts of team members during idea generation.
51	IL provides sufficient time for team members to implement and commercialise new ideas.
16	IL assembles resources effectively to create an ideal setting/environment for successful idea generation efforts to occur in.
32	IL screens ideas in a transparent fashion based on clear evaluation criteria that is readily available and team members.*
47	IL informs team members that proof of an idea's feasibility will be reflected by way of evidence and factual data gathered during feasibility research.*
65	IL formulates marketing strategies that effectively caters to the unique needs of our target market during the commercialisation process.*
44	IL effectively utilises the positive and negative feedback obtained during the feasibility phase to refine and adjust the feasibility research process accordingly.
61	IL successfully uses information gathered from market research activities to revise and/or adjust the commercialisation strategy.
33	IL values the opinions of potential customers/clients during the screening of new ideas.*
37	IL values the ideas, suggestions and critique of prospective customers/clients during feasibility research.
67	IL knows that the cultural differences of our customers/clients will influence their decision whether or not to adopt our products, services or processes during commercialisation.
40	IL handles the criticism of potential customers and clients during the feasibility phase in a constructive manner.
4	IL constantly monitors the environment to generate new ideas and capitalise on the opportunities and threats that exist in the external environment.
57	IL times the entry and introduction of our products, services or processes into the market effectively during commercialisation.
62	IL constantly monitors the external environment for new commercialisation opportunities.
66	IL successfully conducts benchmarking studies/comparisons during commercialisation with competitors in our industry.
26	IL successfully screens new ideas in terms of current trends, opportunities and threats he/she observes in the external environment.*
27	IL screens new ideas in relation to the core business of our team and its markets.*
52	IL is aware of resources that are required to implement and commercialise an idea into the market successfully.

APPENDIX G:
EXAMPLES OF CORRESPONDENCE

Survey respondents discussed in Chapter 4 received notification correspondence through either direct invitations from the researcher or peer-forwarded invitations to make theme aware of the study and to participate of they met the eligibility requirements.

G.1 Direct invitation examples:

Dear Kanchana,

I would like to notify you in advance that you will be receiving an invitation to join my PhD research into the skills used by leaders that have led teams from knowledge to successful technology innovation in SA-governed organisations. Eligible leaders who complete a 20 minute confidential online survey will receive a summarised report of the research findings. The context and invitation message below sets the scene.

This study uses a snowball sampling method and your name was put forward by Henra Mayer and Zander Powell from Innocentrix who identified you as someone with particularly relevant interests and experience. You can help to enhance the value of this research by completing the survey and/or add other candidates by sending me their email details.

I joined Stellenbosch University in 2011 to focus on innovation as an emerging management discipline after a multi-faceted career filled with innovation challenges and learning curves in several industries (automotive, ICT, etc) and 20 years with the CSIR. While the commercialisation of research and innovation outputs occupied much of my time I also had corporate responsibilities for research and innovation capacity building and strategic human capital development.

The pilot study yielded excellent results and if further data supports my case, the findings may bring valuable new insights to technology innovation leaders. An international community of innovation leaders wants to join the research which would elevate findings to international levels of relevance and we are exploring the options at the moment.

Please contact me for any additional information or clarification.

Trusting this would be of interest to you and looking forward to your contribution.

Best regards

Awie Vlok

G.2 Peer-forwarded examples:

a. Da Vinci TT100 Awards Programme message by Prof B Anderson

Dear TT100 Colleague

A PhD research associate from Stellenbosch University has extended his doctoral survey to our community and more specifically techno-innovation leaders who have led a team(s) from new knowledge or ideas to implemented technology innovation in either commercial or public good environments. If you or others in your network have had such experience, please contribute to and learn from the results of his survey in which you answer a few innovation questions and rate the significance of identified leader competencies. Respondents will receive a summary of the findings. Responses are anonymous and confidential as required by the ethics clearance granted by the university. To access the 20-minute online survey, a link will be provided by Awie Vlok, the researcher, who can be contacted at avlok@sun.ac.za.

This study investigates technology innovation leader competencies associated with successful technology innovation by learning from experienced leaders.

Ideal participants are people with current or previous responsibility for technology innovation at South African governed technology enterprises, research and innovation laboratories, science councils, universities and joint ventures.

Your participation within two weeks of receipt is much appreciated.

Regards

Prof B Anderson

b. SAINE (South African Innovation Network)

Dear SAINE members,

We occasionally receive requests for SAINE involvement in projects that may benefit our innovation community. The request below appears to be of direct relevance to many of our members and is sent to you for consideration and involvement in helping to generate new scientifically derived knowledge of technology innovation leaders. The researcher plans to publish the final results and is willing to share key findings with participants.

Your participation is encouraged.

Regards

Neville/Nosipho

saine innovation network

Dear SAINE members,

Your previous or current involvement in technology innovation can help us to develop a better understanding of the leader behaviours that are required for successful technology innovation.

If you have been appointed, or emerged as a leader, or worked in a team that created and implemented technology innovation, please share your opinions by completing the confidential survey available at the link below. If you can think of anyone else in your network whose participation can add value to this study, please forward this message to them for consideration.

Link: https://sunsurveys.sun.ac.za/Survey.aspx?s=992f6e90335443a7b98deb9f2ede343a

Additional information if needed:

- Despite the challenges involved in turning new knowledge into technology innovations, some leaders of technology innovation teams have achieved success.
- There is growing evidence that the innovation economy requires leadership competencies that may differ from those required for operational management. Technology innovation is seen by many as a major driver of economic growth globally and in South Africa, as reflected in strategy and policy statements.
- "A competency profile for technology innovation leaders in knowledge-intensive organisations in South Africa" is the title of a doctoral study being conducted by Awie Vlok from Stellenbosch University (contact details below). This research has incorporated extensive literature studies, expert interviews across the research and innovation landscape, case analyses and workshops. This has culminated in an interim set of leader competencies that are now being rated by technology innovation leaders to determine their significance in achieving successful technology innovation.
- Ideal respondents are people currently or previously responsible for technology innovation at South African governed organisations such as innovation inspired technology enterprises, research and innovation laboratories, science councils and universities.
- This study takes place within the ethical clearance parameters of Stellenbosch University which means that participation is anonymous, voluntary and confidential.

Your participation during June 2016 is much appreciated.

Regards

Awie Vlok

Innovation Scholar - Stellenbosch University

Contact details: avlok@sun.ac.za; Mobile 0828929350

APPENDIX H:

PILOT SURVEY QUESTIONNAIRE

A competency profile for technology innovation leaders in knowledge-intensive organisations in South Africa	
This PhD survey takes approximately 14 minutes to complete after which responses are automatically submitted to the survey administrator. at https://sunsurveys.sun.ac.za/A-competency-profile-for-technology-innovation-leaders-in-knowledge-intensive-organisations-in-South-Africa.aspx?forceNew=true&test=true. The researcher is Awie Vlok who may be contacted at avlok@sun.ac.za	
INFORMED CONSENT: I hereby confirm my voluntary participation in this study in line with ethical clearance requirements of Stellenbosch University. [Hover the mouse cursor over the informed consent for a brief summary of the governing principles]	Principles: i)No harm to any research subject or organisation taking part, which may be not only individuals, but also the organisation that the research subjects belong to, ii) Respect for the rights of people in deciding to take part in research or not, iii) Respect for the continued rights of research participants after they have opted to take part, vi)The absence of any form of coercion in getting people to participate and v)Total transparency about the research and its potential risks before the researcher can expect people to make decisions about taking part.

PART 1: BIOGRAPHICAL DETAILS OF RESPONDENT	
INSTRUCTIONS: Please indicate your gender, age, qualification, discipline, technology innovation leader role, job level, firm size and firm type.	
Gender	
	Male/Female
Age (number of years)	
Highest qualification	
	School/ College/ B degree/ Honours degree/ Master's degree/ PhD
Main discipline studied	
	Technician/ Natural sciences/ Behavioural sciences/ Business management/ Engineering/ Other (specify):
Job focus	
	Junior management/ middle management/ senior/executive management/ technical domain specialist/ Functional domain specialist
Firm size (Number of employees)	
	2 to 50/ 51 to 200/ 201 to 500/ 501 to 1000/ 1001 to 5000/ above 5000
Firm type	
	SME/ University/ Research council/ Industry/ Consulting/ Other (specify):

PART 2: INTRODUCTORY QUESTIONS.						
INSTRUCTIONS: Please indicate your level of agreement or disagreement with the statements below.						
	Based on my exposure to successful technology innovation leaders I believe that:	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	Successful technology innovation is achieved when imagined possibilities are turned into technology that is implemented or adopted and delivers quantifiable improvement (e.g. in quantity, quality, time, or cost) over previously-used technology or practices.	1	2	3	4	5
2	Technology innovation processes are often portrayed as linear and sequential with the technology innovation leader applying phase-specific skills in each phase. In real practice, successful technology innovation leaders require the following clusters of competencies that may be applied in different sequences.	1	2	3	4	5
	a. Competencies for being connected to evolving technology innovation and knowledge landscapes	1	2	3	4	5
	b. Competencies for achieving stakeholder alignment	1	2	3	4	5
	c. Competencies for liberating mind-sets	1	2	3	4	5
	d. Competencies for value creation (perceived by stakeholders as value)	1	2	3	4	5
	e. Competencies for value realisation (deriving returns from innovation)	1	2	3	4	5
	f. Competencies for integrative leadership	1	2	3	4	5
INSTRUCTIONS: Please select ONE of the 10 technology progress levels below to indicate the success level of the technology innovation that you will think of when rating the perceived significance of each of the leader competencies listed in PART 3:						
3	The success status of the technology innovation that I will think of when rating the leader competencies in PART 3. [Hover the mouse cursor over the technology innovation success status levels below for a brief explanation.]	Explanation of technology innovation success status levels based on technology readiness levels (TRLs) to answer the next question				
	1. Basic principles observed and reported.	Lowest technology readiness level. Scientific research begins to be translated into applied research and development (R&D). May include studies of a technology's basic properties. Research results identify principles that underlie this technology.				
	2. Technology concept and/or application formulated.	Invention begins. Practical applications can be invented based on basic principles. Applications are speculative, and there may be no proof or detailed analysis to support the assumptions. Examples include analytic studies, publications or other references that outline the innovative application being considered.				

	3. Proof of concept and/or analytical and experimental critical function assessment.	May include R&D, including analytical studies and laboratory studies to physically validate the analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative. Laboratory testing to measure parameters of interest and comparison to analytical predictions for critical subsystems.
	4. Component validation in laboratory environment.	Basic technological components are integrated to establish that they will work together before the eventual system is tested. May include integration of "ad hoc" hardware in the laboratory. System concepts that have been considered and results from testing laboratory scale breadboard(s). Provide estimates of how breadboard hardware and test results differ from the expected system goals.
	5. Component validation in relevant environment.	Components are integrated with reasonably realistic supporting elements so that they can be tested in a simulated environment. Results answer questions like: How does the "relevant environment" differ from the expected operational environment? How do the test results compare with expectations? What problems, if any, were encountered? Was the breadboard system refined to match the expected system goals more closely?
	6. Prototype demonstration in a relevant environment.	System/subsystem model or representative model or prototype system, which is well beyond that of TRL5, is tested in a relevant environment. Represents a major step-up in a technology's demonstrated readiness.
	7. Prototype demonstration in an operational environment.	Prototype near or at planned operational system. Represents a major step-up from TRL6 by requiring demonstration of an actual system prototype in an operational environment (e.g. in an aircraft, in a vehicle, or in space).
	8. Complete system test.	Technology is proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Test results are used to analyse problems, if any were encountered. What are/were the plans, options, or actions to resolve problems before finalising the design?
	9. Complete system proven in operation.	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation.
	10. Actual system adopted by the market and made or still making impact.	The technology innovation has been implemented and those who adopted it are deriving value from its use.

PART 3: RATING OF LEADER COMPETENCIES DEEMED TO BE REQUIRED FOR SUCCESFUL TECHNOLOGY INNOVATION						
INSTRUCTIONS: Please evaluate the extent to which each of the following leader competencies listed are deemed to be required for successful technology innovation (realised value). Consider technology innovation success(es) that you have been exposed to before when you express your view on the 5-point rating scale.						
*Technology innovation leader **competencies***		*Your **rating** (best descriptor)*				
Capability cluster 1: Being connected with the evolving technology innovation landscape to conceptualise new possibilities.		To no extent	To a little extent	To some extent	To a great extent	To a very great extent
1	The technology innovation leader builds rich and varied ways or **channels** to stay informed of new knowledge and technology innovations to inform unit technology innovation decisions.	1	2	3	4	5
2	The technology innovation leader maintains effective networks to **access content sources of expertise** and of the latest science and technology developments that may influence the firm's technology innovation.	1	2	3	4	5
3	The technology innovation leader builds absorptive surveillance capacity in the unit to **collectively track and process** early signals of emerging technology changes that may influence the operating landscape of the unit.	1	2	3	4	5
4	The technology innovation leader maintains on-going learning (technical and business) to enhance **own credibility** as thought leader.	1	2	3	4	5
5	The technology innovation leader visualises wider imaginary applications from new knowledge and technology beyond current reality in **anticipation of possible future technology innovation.**	1	2	3	4	5
6	The technology innovation leader **considers innovation opportunities** related to the strategic intent of the unit for future technology innovation.	1	2	3	4	5
7	The technology innovation leader selects innovation priority areas with the potential to strengthen the strategic future **value of the unit innovation pipeline and portfolio.**	1	2	3	4	5
8	The technology innovation leader detects the **early signals** of emerging opportunities, challenges, problems, players and landscape dynamics as inputs into technology innovation decisions.	1	2	3	4	5
9	The technology innovation leader **explores** the larger PESTLE (Political, Economic, Sociological, Technological, Legal, and Environmental) environment continuously for technology innovation possibilities.	1	2	3	4	5
10	The technology innovation leader **models** (e.g. business models and technology road maps) alternative futures based on the influence of anticipated technology landscape changes on the competitiveness of the unit.	1	2	3	4	5

	Capability cluster 2: Mobilising stakeholder alignment, support and participation	To no extent	To a little extent	To some extent	To a great extent	To a very great extent
1	The technology innovation leader identifies and interacts with stakeholders (opinion shapers and decision-makers), building personal **trust-based relationships** with individuals inside and outside the unit that may influence or contribute to technology innovation of the unit.	1	2	3	4	5
2	The technology innovation leader **understands** the needs, political agendas, roles and expectations of stakeholders in relation to anticipated technology innovation.	1	2	3	4	5
3	The technology innovation leader is effective in **obtaining support** for the anticipated technology innovation by making stakeholders understand potential benefits of the new over the current for the respective stakeholders.	1	2	3	4	5
4	The technology innovation leader **secures resources** that are required for the anticipated technology innovation of the unit, including interaction time of decision-makers.	1	2	3	4	5
5	The technology innovation leader aligns stakeholder requirements through beneficial or **compelling images** of technology futures that leave stakeholders with a sense of urgency and excitement in anticipation of the envisaged technology innovation.	1	2	3	4	5
6	The technology innovation leader **attracts enthusiastic competent innovation talent** to consider as potential team members with complementary profiles and abilities to add value to technology innovation.	1	2	3	4	5
7	The technology innovation leader avoids, anticipates, detects and **resolves tensions or conflicts** between entities and conflicts of interests pertaining to the technology innovation envisaged.	1	2	3	4	5
8	The technology innovation leader establishes **effective governance and communication mechanisms** through which stakeholders stay informed and influence the development during the envisaged technology innovation.	1	2	3	4	5
9	The technology innovation leader develops **innovation design parameters** based on requirements and **motive**s of decision-makers and opinion leaders.	1	2	3	4	5
	Capability cluster 3: Liberating mindsets	To no extent	To a little extent	To some extent	To a great extent	To a very great extent
1	The technology innovation leader ensures **innovation team diversity** by appointing open-minded members with diverse experiences, backgrounds, disciplines and competencies and personal attributes needed to realise the technology innovation vision.	1	2	3	4	5
2	The technology innovation leader creates an **innovation conducive environment through purpose-directed, values-based rules of engagement** for team interactions that optimise member contributions through exchange and discussion of ideas and sensitive information without having to fear victimisation.	1	2	3	4	5

3	The technology innovation leader stimulates and **provokes unfamiliar or unconventional ideas and thinking** as building blocks towards the achievement of the technology innovation vision.	1	2	3	4	5
4	The technology innovation leader **uses effective idea generation and sharing techniques** (e.g. brainstorming sessions, focus group discussions and strategy sessions) to overcome entrenched beliefs and habits.	1	2	3	4	5
5	The technology innovation leader establishes **effective idea capturing mechanisms** allowing people to effortlessly submit ideas they have generated (e.g. suggestion box, including the forums).	1	2	3	4	5
6	The technology innovation leader facilitates **integrative technology solutions or improvements** through systems and whole-brain thinking by the team in assessing ideas in terms of their contribution towards the technology innovation vision and performance goals.	1	2	3	4	5
7	The technology innovation leader fosters constructive positive **team dynamics and resolves people tensions** without delay so that the team can channel their creative energies towards the innovation vision.	1	2	3	4	5
8	The technology innovation leader establishes routines and capabilities in the team to **spot possible technology improvement areas and determine the feasibility** of new ideas.	1	2	3	4	5
9	The technology innovation leader aims to ideate **technology innovation-based value improvement for a stakeholder** rather than adhering to highly detailed work plans and tight control during ideation as it will inhibit creativity efforts of team members.	1	2	3	4	5
10	The technology innovation leader ensures that technology innovation **design parameters are contextualised** by framing problems, challenges, opportunities and requirements to solicit original thinking.	1	2	3	4	5
Capability cluster 4: Facilitation of value creation		To no extent	To a little extent	To some extent	To a great extent	To a very great extent
1	The technology innovation leader establishes effective practices for converting promising but still vague concepts into **concrete tangible value manifestations** such as prototypes, technology demonstrators, and experimental designs that illustrate what the technology can do.	1	2	3	4	5
2	The technology innovation leader re-constitutes the technology innovation team if needed to ensure that required capabilities (like skills, equipment and infrastructure) are available for testing and refining and producing **technology innovations perceived to be valuable** by stakeholders.	1	2	3	4	5
3	The technology innovation leader establishes effective individual and collective team capabilities to solicit and process **stakeholder feedback** that may be used to enhance future demand for the invention.	1	2	3	4	5

4	The technology innovation leader acknowledges the potential destruction or disruption of current technologies that may come with new technology innovation and crafts **effective technology implementation pathways and change management** to avoid unintended negative consequence.	1	2	3	4	5
5	The technology innovation leader facilitates **simulation and exploration** of technology parts and configurations to consider customisation for different applications and stakeholder segments.	1	2	3	4	5
6	The technology innovation leader facilitates effective decision making by all involved to reach informed **stop-or-go decision**s based on agreed and shared criteria that combine disparate or even opposing ideas.	1	2	3	4	5
7	The technology innovation leader establishes effective mechanisms to identify and protect new **intellectual property** flowing from team deliberations.	1	2	3	4	5
8	The technology innovation leader conducts rapid experimentation, value modelling and progress assessments to **enhance technology readiness and adoption readiness levels** of the new technology for introduction to and adoption by targeted individuals and groups.	1	2	3	4	5
9	The technology innovation leader networks effectively with members from other departments and business units to create cross-functional **collaborative commercialisation teams** to ensure adoption of the new technology (alone or as products, services or processes).	1	2	3	4	5
10	The technology innovation leader establishes **effective collaborative innovation** through effective negotiation with collaborators and partners to commercialise our products, services and/or processes successfully into the market or value chain.	1	2	3	4	5
Capability cluster 5: Facilitation of value realisation		To no extent	To a little extent	To some extent	To a great extent	To a very great extent
1	The technology innovation leader facilitates the development of a **market penetration model and strategy** (e.g.3rd party licensing, sale or own commercialisation start-up) in which critical success factors for market entry are identified and accommodated.	1	2	3	4	5
2	The technology innovation leader facilitates **co-creation of whole product solutions** with beneficiaries to ease adoption (for "crossing the chasm") during the technology introduction and diffusion phases.	1	2	3	4	5
3	The technology innovation leader uses networks, client demands, regulatory forces and success stories to achieve **market allegiance** for the new technology to become the standard (also called dominant design) for specifiers and regulators of technology solutions (stakeholders).	1	2	3	4	5
4	The technology innovation leader provides **educational support on new technologies** (to address fear uncertainty and doubt) for smooth implementation and adoption of technology innovations in support of sales and marketing activities of the unit.	1	2	3	4	5

5	The technology innovation leader maintains **agile responsive capacity** in the innovation team to monitor and respond to anticipated and un-anticipated implementation challenges (technology and market).	1	2	3	4	5
6	The technology innovation leader establishes an **innovation eco-system** that keeps the innovation members and stakeholders networked for on-going learning and refinement of technology innovation practices.	1	2	3	4	5
7	The technology innovation leader facilitates **effective transfer of the new technology** in line with the selected commercialisation business model.	1	2	3	4	5
8	The technology innovation leader monitors and manages technology **deployment** levels in line with demand levels and production capabilities.	1	2	3	4	5
9	The technology innovation leader explores technology **platform expansion/scaling** opportunities and applications to enhance financial returns on investments through on-going symbiotic relationships with all involved in supply chain delivery.	1	2	3	4	5
10	The technology innovation leader engages **on-going technology innovation support** to broaden understanding of potential future technology innovation opportunities, such as R&D and innovation communities.	1	2	3	4	5
Capability cluster 6 : Integration through leadership		To no extent	To a little extent	To some extent	To a great extent	To a very great extent
1	The technology innovation leader leads by example as **role model** in original thinking, exploring opportunities, generating ideas, learning from experience and determining the feasibility of ideas for value creation and value realisation with strong emphasis throughout on the interrelatedness of all innovation activities.	1	2	3	4	5
2	The technology innovation leader develops and communicates an **inspirational and intellectually challenging innovation vision** and strategic purpose to scope the preferred types of innovation and direction for the innovation team. This may include problems, challenges or opportunities.	1	2	3	4	5
3	The technology innovation leader **engages** people before initiating changes that may affect them, incorporating their ideas and suggestions in innovation processes and decisions.	1	2	3	4	5
4	The technology innovation leader **empowers** members by establishing shared ownership and allowing members sufficient freedom and autonomy to determine by themselves or with others how to meet their innovation objectives. This includes being allowed to make mistakes and learn from them.	1	2	3	4	5
5	The technology innovation leader **supports and motivates** members by giving them space to do what they value, both in times of passion and pain. This includes acting friendly, showing respect, being patient and helpful, listening, and looking out for someone's interests if problems arise.	1	2	3	4	5

6	The technology innovation leader uses **recognition and reward mechanisms to show appreciation** for innovative performances of those involved to acknowledge innovation contributions of team members.	1	2	3	4	5
7	The technology innovation leader oversees on-going innovation progress and **provides constructive timely feedback** to team members during innovation to learn from success and failures during innovation.	1	2	3	4	5
8	The technology innovation leader radiates **positive innovation energy** rooted in positive attitude, group dynamics and organisational support for vision-aligned technology innovation.	1	2	3	4	5
9	The technology innovation leader **facilitates systemic integration** of technology innovation through alignment of all elements (technical, human, business).	1	2	3	4	5
10	The technology innovation leader provides an overarching broadly-defined **innovation architecture, logical framework and/or structured project plan** (design, elements, structure, resources and flow) that aim to achieve collective progressive technology innovation towards the innovation vision or goals.	1	2	3	4	5
11	The technology innovation leader solicits intense near-**obsession-like levels of ownership** for generating solutions to innovation challenges opportunities or problems.	1	2	3	4	5

APPENDIX I:

FINAL QUESTIONNAIRE FOR MAIN SURVEY

A competency profile for technology innovation leaders in knowledge-intensive organisations in South Africa	
This three-part survey takes about 20 minutes to complete online. Completed responses are automatically submitted to the survey administrator. Participation is anonymous, confidential and voluntary in line with the ethical clearance requirements of Stellenbosch University. The researcher is Awie Vlok who may be contacted at avlok@sun.ac.za or 0828929350. If you are interested in the findings of this study, please provide your email:	
PART 1: BIOGRAPHICAL DETAILS OF RESPONDENT	
INSTRUCTIONS: Please provide the following information which will only be used for sample analysis.	
Gender	Male/Female
Age (number of years) - optional field	
Number of years as technology innovation leader	
Highest qualification	
Main discipline studied	Technician/ Natural sciences/ Behavioural sciences/ Business management/ Engineering/ Other (specify):
Job focus	Junior management/ middle management/ senior/executive management/ technical domain specialist/ Functional domain specialist/ Other (specify):
Organisation size (Number of employees)	
Organisation type	SME/ University/ Research council/ Industry/ Consulting/ Other (specify):

PART 2: INTRODUCTORY QUESTIONS

INSTRUCTIONS: Please indicate your level of agreement or disagreement with the statements below.

	Based on my exposure to successful technology innovation I believe that:	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	Technology innovation is achieved when value is derived from its adoption or deployment.	1	2	3	4	5
2	Technology innovation leaders may not follow a linear sequential technology innovation process but apply (the following) clusters of competencies in context-specific different sequences.	1	2	3	4	5
	a. Competencies for being connected to evolving technology innovation and new knowledge.	1	2	3	4	5
	b. Competencies for achieving stakeholder alignment and support.	1	2	3	4	5
	c. Competencies for liberating mindsets of those involved.	1	2	3	4	5
	d. Competencies for value creation (perceived by stakeholders as value).	1	2	3	4	5

	e. Competencies for value realisation (deriving returns from innovation)	1	2	3	4	5
	f. Competencies for leading integration of innovation elements (technical, business, people)	1	2	3	4	5
INSTRUCTIONS: Please select value descriptor(s) that best reflect what you regard as successful technology innovation.						
3	For me successful technology innovation implies:	To no extent	To a little extent	To some extent	To a great extent	To a very great extent
3.1	Technical gain					
	a. Unlocks new functional possibilities	1	2	3	4	5
	b. Improves productivity (output/input%)	1	2	3	4	5
	c. Solves problem(s)	1	2	3	4	5
3.2	Business gain					
	a .Yields financial value	1	2	3	4	5
	b. Gains market advantage	1	2	3	4	5
	c. Initiates viable new ventures	1	2	3	4	5
3.3	People benefit					
	a. Improves human interface design	1	2	3	4	5
	b. Achieves socio-economic impact	1	2	3	4	5
	c. Skilled human capital	1	2	3	4	5
3.4	Radical innovation (new components and new configuration)	1	2	3	4	5
PART 3: RATING OF LEADER COMPETENCIES DEEMED TO BE REQUIRED FOR SUCCESFUL TECHNOLOGY INNOVATION						
INSTRUCTIONS: Please indicate the extent to which you regard each of the listed leader competencies as being important for successful technology innovation.						
Technology innovation leader competencies		Your **rating** (best descriptor)				
Capability cluster 1: Being connected with evolving technology innovation and knowledge landscapes to conceptualise new possibilities.		To no extent	To a little extent	To some extent	To a great extent	To a very great extent
1	The technology innovation leader uses various **channels** to stay informed of new knowledge and technology innovations.	1	2	3	4	5
2	The technology innovation leader builds effective networks to **access expert views** on science and technology developments.	1	2	3	4	5
3	The technology innovation leader builds capacity to **track** evolving technologies that may influence innovation decisions.	1	2	3	4	5
4	The technology innovation leader maintains on-going learning (technical and business) to enhance **own credibility** as thought leader.	1	2	3	4	5
5	The technology innovation leader **imagines innovative future applications from new** knowledge and technology beyond current reality.	1	2	3	4	5

6	The technology innovation leader considers technology **innovation opportunities that relate to the strategic intent** of the organisation.	1	2	3	4	5
7	The technology innovation leader **selects innovation priority areas** with the greatest potential to strengthen the future value of the innovation portfolio.	1	2	3	4	5
8	The technology innovation leader detects **early signals** of innovation landscape changes (such as opportunities, challenges, players and landscape dynamics) as inputs into technology innovation decisions.	1	2	3	4	5
9	The technology innovation leader **explores** the larger PESTLE (political, economic, social, technological, legal and environmental) environments for technology innovation possibilities.	1	2	3	4	5
10	The technology innovation leader **contemplates** technology innovation scenarios to accommodate uncertainty and risk in technology landscape trajectories.	1	2	3	4	5
Capability cluster 2: Achieving stakeholder alignment, support and participation		To no extent	To a little extent	To some extent	To a great extent	To a very great extent
1	The technology innovation leader builds personal **trust-based relationships** inside and outside the organisation with individuals (opinion shapers and decision-makers) that may influence or contribute to technology innovation of the innovation team.	1	2	3	4	5
2	The technology innovation leader **understands stakeholders' interests** in relation to technology innovation.	1	2	3	4	5
3	The technology innovation leader **obtains stakeholder support** for technology innovation by making them understand the benefits of the new over the current technology or practices.	1	2	3	4	5
4	The technology innovation leader **secures resources** required for technology innovation.	1	2	3	4	5
5	The technology innovation leader conveys **compelling images** of technology futures to align stakeholder expectations with features and benefits of the envisaged technology innovation.	1	2	3	4	5
6	The technology innovation leader **attracts enthusiastic competent innovation talent** to consider as potential team members.	1	2	3	4	5
7	The technology innovation leader manages **tensions** between stakeholders affected by the technology innovation.	1	2	3	4	5
8	The technology innovation leader establishes **mechanisms** through which stakeholders stay informed and supportive of the technology innovation.	1	2	3	4	5
9	The technology innovation leader develops **innovation design parameters** based on requirements and motives of decision-makers and opinion leaders.	1	2	3	4	5

Capability cluster 3: Liberating mindsets		To no extent	To a little extent	To some extent	To a great extent	To a very great extent
1	The technology innovation leader ensures **innovation team diversity** by having open-minded members with diverse experiences, backgrounds, competencies and personal attributes needed to realise the envisaged technology innovation vision.	1	2	3	4	5
2	The technology innovation leader creates an **innovation conducive environment** where members engage freely in **exchanging** ideas and sensitive information.	1	2	3	4	5
3	The technology innovation leader **provokes unconventional thinking** as building blocks towards the technology innovation vision.	1	2	3	4	5
4	The technology innovation leader facilitates creative thinking practices to overcome entrenched beliefs to evolve to **new possibility paradigms**.	1	2	3	4	5
5	The technology innovation leader uses effective mechanisms to **capture** promising ideas for consideration.	1	2	3	4	5
6	The technology innovation leader facilitates **integrative solutions thinking** in support of the technology innovation vision.	1	2	3	4	5
7	The technology innovation leader fosters constructive team dynamics for members to **focus their creative energies** towards the innovation vision.	1	2	3	4	5
8	The technology innovation leader establishes team routines to **spot additional viable technology improvement possibilities** during the innovation process.	1	2	3	4	5
9	The technology innovation leader aims to ideate technology innovation-based value improvement for stakeholders rather than adhering to highly detailed work plans and tight controls that may inhibit creative efforts of team members.	1	2	3	4	5
10	The technology innovation leader **contextualises innovation by framing** problems, challenges, opportunities and requirements for team members to understand their significance.	1	2	3	4	5
Capability cluster 4: Facilitation of value creation		To no extent	To a little extent	To some extent	To a great extent	To a very great extent
1	The technology innovation leader facilitates conversion of promising but still vague concepts into **prototypes** or technology demonstrators that illustrate what the technology can do.	1	2	3	4	5
2	The technology innovation leader adjusts innovation team composition in line with changing capability requirements for maximising stakeholders' **perceived value** from new technology.	1	2	3	4	5
3	The technology innovation leader solicits **stakeholder perspectives** that may enhance the future value of the technology innovation.	1	2	3	4	5

4	The technology innovation leader anticipates **potential disruption** that may come with new technology innovation to minimise unintended negative consequences.	1	2	3	4	5
5	The technology innovation leader contemplates **alternative technology configuration scaling and customisation options** for different applications and stakeholder segments.	1	2	3	4	5
6	The technology innovation leader facilitates effective decision-making by all involved to reach informed **stop-or-go decisions** based on agreed and shared criteria that combine disparate or even opposing ideas.	1	2	3	4	5
7	The technology innovation leader establishes effective mechanisms to identify and protect new **intellectual property** flowing from team deliberations.	1	2	3	4	5
8	The technology innovation leader explores rapid experimentation of alternatives to **enhance technology readiness** of the new technology for adoption by individuals or groups.	1	2	3	4	5
9	The technology innovation leader effectively engages other departments (functional entities) in cross-functional **commercialisation teams** for introduction of the new technology.	1	2	3	4	5
10	The technology innovation leader negotiates **effective collaborative innovation** arrangements with collaborators and partners for adoption of the new technology.	1	2	3	4	5
Capability cluster 5: Facilitation of value realisation		To no extent	To a little extent	To some extent	To a great extent	To a very great extent
1	The technology innovation leader facilitates the development of a **market entry framework** (business model and strategy) for new technology to derive value.	1	2	3	4	5
2	The technology innovation leader facilitates **co-creation of whole-product solutions with stakeholders** to ease new technology adoption (core technology augmented with additional elements to provide compelling value).	1	2	3	4	5
3	The technology innovation leader **ensures technical support** for the new technology to become the standard for specifiers and regulators of technology solutions.	1	2	3	4	5
4	The technology innovation leader provides **educational support on new technologies** for smooth implementation and adoption of the new technology innovations.	1	2	3	4	5
5	The technology innovation leader maintains **capacity** in the innovation team to respond to implementation challenges (technology and market).	1	2	3	4	5

6	The technology innovation leader keeps the **innovation team members and stakeholders networked** during technology deployment for on-going learning and refinement of technology innovation practices.	1	2	3	4	5
7	The technology innovation leader facilitates **effective transfer of new technology** (including skills and knowledge) to its adopters.	1	2	3	4	5
8	The technology innovation leader facilitates ballancing of technology **deployment** requirements with technology delivery capabilities and capacity.	1	2	3	4	5
9	The technology innovation leader explores technology **expansion/scaling opportunities** for greater value yields through collaborative supply chain relationships.	1	2	3	4	5
10	The technology innovation leader engages **on-going technology innovation support** to broaden understanding of potential future technology innovation opportunities, such as R&D and innovation communities.	1	2	3	4	5
Capability cluster 6: Leading integration of innovation elements		To no extent	To a little extent	To some extent	To a great extent	To a very great extent
1	The technology innovation leader leads by example as **role-model** in original thinking, exploring opportunities, generating ideas, learning from experience and determining the feasibility of ideas for value creation and value realisation with strong emphasis throughout on the interrelatedness of all innovation activities.	1	2	3	4	5
2	The technology innovation leader develops and articulates an intellectually challenging technology innovation **vision and strategic purpose** towards which innovation team members feel inspired to contribute.	1	2	3	4	5
3	The technology innovation leader **engages people** before initiating changes that may affect them, incorporating their ideas in the technology innovation processes.	1	2	3	4	5
4	The technology innovation leader **empowers** members through shared ownership and agreed autonomy to determine by themselves how to meet their innovation objectives. This includes being allowed to make mistakes and learn from them.	1	2	3	4	5
5	The technology innovation leader **motivates** members by providing support for what they value, both in times of passion and pain. This includes caring for their development, acting friendly, showing respect, being patient and helpful, listening, and looking out for someone's interests if problems arise.	1	2	3	4	5
6	The technology innovation leader uses recognition and reward mechanisms to show **appreciation** for innovation contributions of team members.	1	2	3	4	5

7	The technology innovation leader **provides constructive timely feedback** to team members during innovation to learn from successes and failures during innovation.	1	2	3	4	5
8	The technology innovation leader radiates **positive innovation energy** rooted in positive attitude, group dynamics and organisational support for vision-aligned technology innovation.	1	2	3	4	5
9	The technology innovation leader **facilitates systemic integration** of technology innovation through alignment of all elements (technical, human, business).	1	2	3	4	5
10	The technology innovation leader maintains an overarching broadly-defined **innovation framework plan** to guide progress towards the envisaged technology innovation.	1	2	3	4	5
11	The technology innovation leader instills a sense of collective identity and responsibility among team members for technology innovation performance.	1	2	3	4	5
	Thank you for your participation!					

APPENDIX J:
MAIN STUDY FEEDBACK

As mentioned in Chapter 6 and analysis of non-responses revealed the following categories of explanations based on feedback received.

Regulatory and policy reasons

- "Requests to participate in surveys or to confirm the accuracy of data used in surveys or to provide additional information used in research engagements arrive at our offices almost daily. To respond to all these requests would be extremely time-consuming. On the other hand, to make exceptions would be unfair. For these reasons it is our company's practise not to participate in research, questionnaires, surveys and other similar projects" – written feedback from Remgro and similar verbal feedback from individuals.
- The PoPI legislation discussed elsewhere prevented effective snowball sampling. Two nominated groups were held back because the person compiling the list was not sure if it was legally permissible to provide names and emails of individuals in their networks.
- Ethics: The first question on the main survey questionnaire requested informed consent for which respondents had to be informed of the voluntary nature of their participation which made at least three respondents decide not to participate.

Technical

- The Sunsurvey system was unable to accommodate more than one active respondent at a time when a static survey link was used.
- Only 100% completed and save survey responses were saved
- Slow processing of answers (TUT Professor)
- Lack of a pause function caused at least three respondents not to complete the survey because of time pressures.
- Some respondents' emails were sent back because the invitations were treated as SPAM messages.
- "I'm sorry I couldn't get the document to save. I've attached the scanned the doc. I'm afraid you will have to enter the info for me." (Dr JD, 25Aug2016).

Personal

- Up to 40% of batch email invitations resulted in automated responses to indicate that the invitee would be absent for some time.

- Time
  - "Evening Awie, Hope you're doing well. I'm not ignoring you just distracted. I've been travelling more now that Im an acting executive for tia. I'll complete the survey now." (Saberi)
  - You can send me the link and I will try to make time (Gerrie)
  - Sal ander name aanstuur so gou ek kans kry (GC)
  - Management of the NSI splits research activities from commercialisation activities with few respondents being able to express views across the full technology innovation process.
  - "...i do not comply to your specifications in terms of technology innovation and I am thus unable to assist) (Dr I Wilson).
  - "greetings Awie and thanks for the persistence. apologies for not responding to your kind invitations to participate. this is a consequence of not having time at the moment. please excuse me, but schedule-wise, i am only able to catchup with your process early next year (should you still be keen?) with the seriousness it requires. warm regards and best wishes, ...r" (RasMaj, 25Aug2016).
  - No thank you. I am over surveyed (C Hamilton, UCT, 25 Aug 2016).

- Competition between entities in the NSI was suggested as a major reason why people were reluctant to share contacts.
- Competition for ideas and resources was suggested as a reason for the reluctance of successful technology innovation leaders to share their practices with others. Financial difficulties in the higher education sector have resulted in austerity measures, including staff reductions (Businesstech, 2016)

Paradigms

- "Universities government agencies have no idea of what goes into successful innovation. They think having IP is like owning crown jewels which in reality does not work like that " – feedback from Frans and Ricus (confidential). Similar views are expressed in an industry leader saying that : Academics and universities...have no management, no muscle, no vision, no business plan and that is 90% of the task of exploiting science and taking it to the market place. There is a tendency for universities to think, 'we invented the thing so we are already 50 percent there'. The fact is that they are 50 percent to nowhere" (Tidd & Bessant, 2013:542).

- "I started on your survey and I have to admit that I didn't get very far into it because it was very technical and required me to read a question several times to make sure that I understand what you mean and expect from the survey participant. You can see that the questions come from a highly specialised knowledge expert. For this reason I am concerned that this will affect the responses."

APPENDIX K:

MAIN STUDY STATISTICS

This appendix includes supplementary descriptive and inferential statistics processed from the main or quantitative research phase to support Chapter 6 discussion.

Section A: Figures

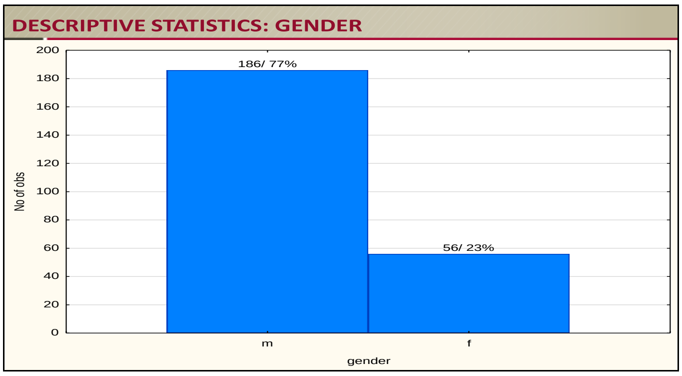

Figure K.1: Descriptive statistics: Gender

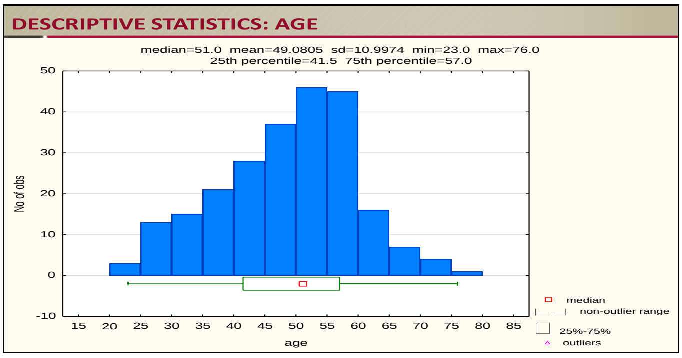

Figure K.2: Descriptive statistics: Age

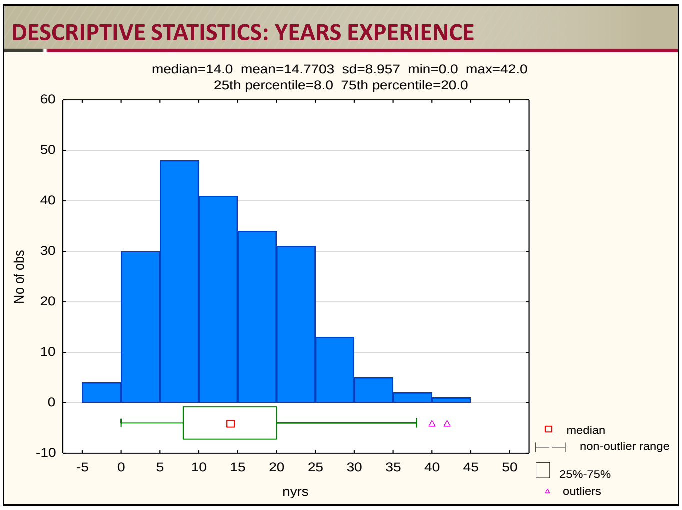

Figure K.3: Descriptive statistics: Years experience

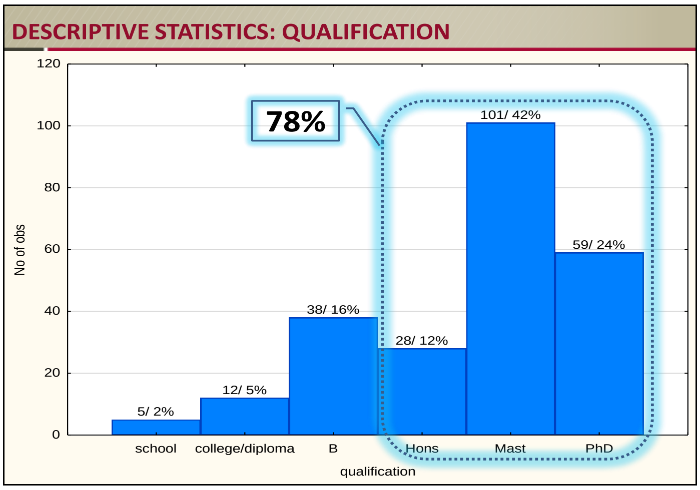

Figure K.4: Descriptive statistics: Highest qualification

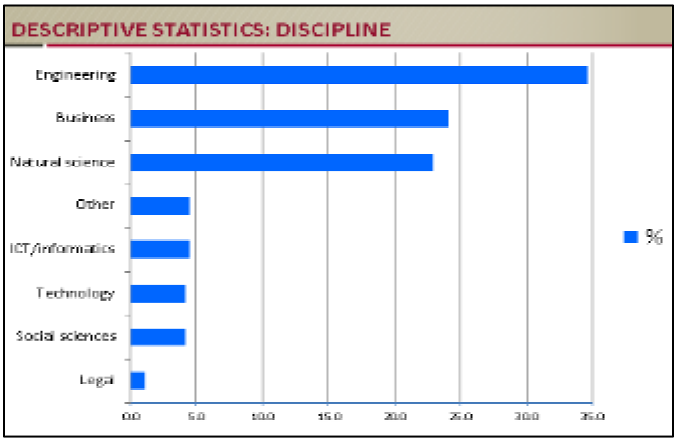

Figure K.5: Descriptive statistics: Discipline studied

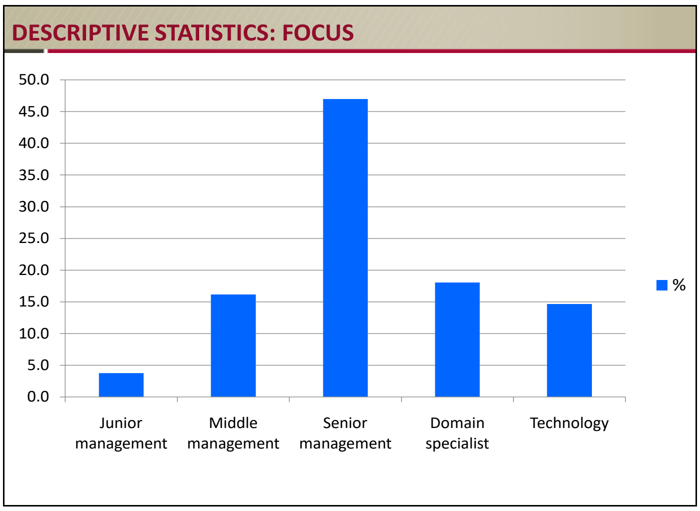

Figure K.6: Descriptive statistics: Focus

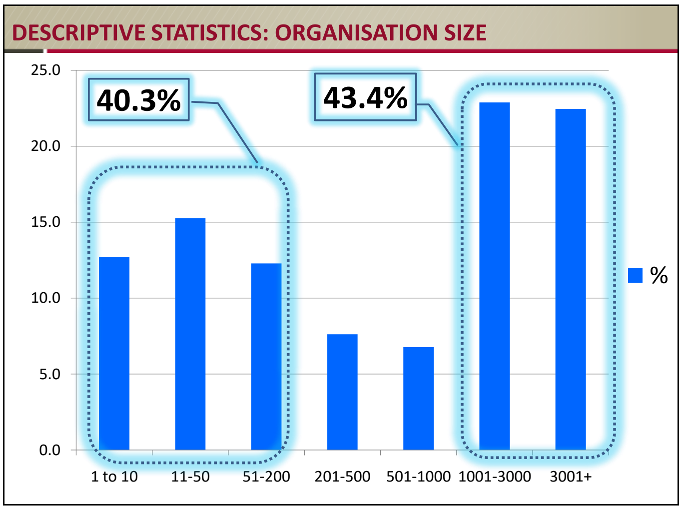

Figure K.7: Descriptive statistics: Organisation size

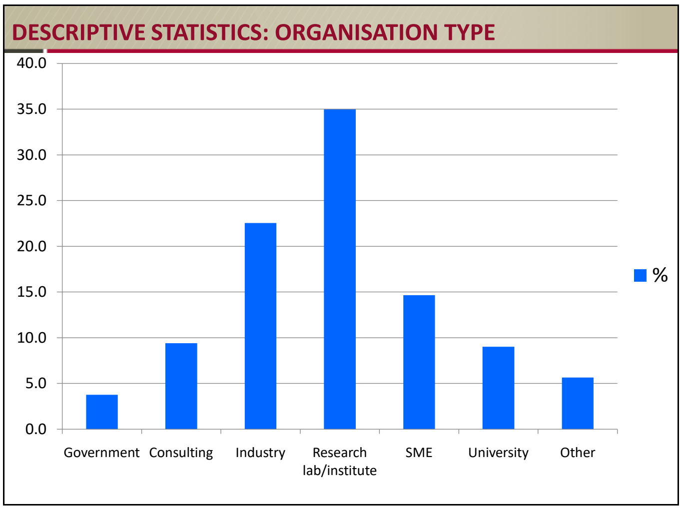

Figure K.8: Descriptive statistics: Organisation type

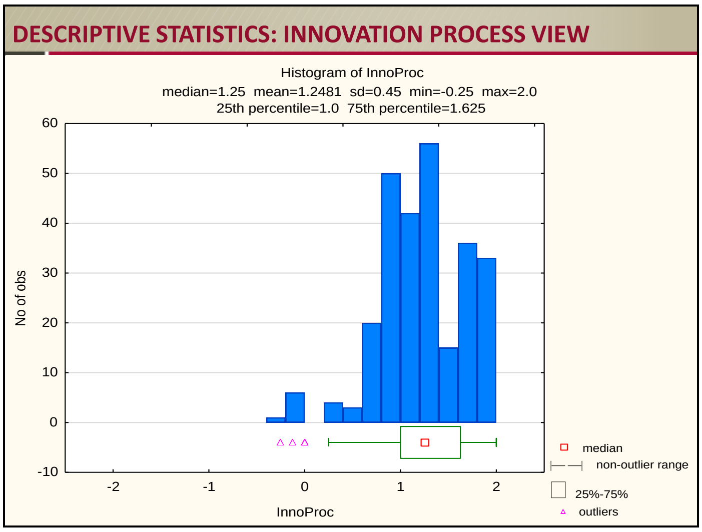

Figure K.9: Descriptive statistics: Innovation process view

Section B: Tables

Table K.1: Outer loadings from SmartPLS-SEM

	Bootstrapping results					Confidence intervals		Confidence intervals bias corrected		
	Sam-ple	Sample mean	Std dev.	*t* value	*p* value	2.50 %	97.50 %	Bias	2.50 %	97.50 %
Fin <- SO	0.542	0.492	0.161	3.357	0.001	0.049	0.698	-0.05	0.177	0.718
Func <- SO	0.648	0.625	0.116	5.582	0	0.384	0.789	-0.023	0.44	0.812
Hint <- SO	0.639	0.597	0.115	5.554	0	0.296	0.739	-0.042	0.453	0.764
IL_C6.1 ROLE_Column2 <- IL	0.478	0.476	0.068	7.061	0	0.33	0.596	-0.002	0.327	0.594
IL_C6.10 FWRK_Column2 <- IL	0.67	0.668	0.046	14.48	0	0.571	0.751	-0.002	0.569	0.75
IL_C6.11 OWN_Column2 <- IL	0.737	0.735	0.051	14.6	0	0.625	0.821	-0.002	0.618	0.818
IL_C6.2 VIS_Column2 <- IL	0.615	0.614	0.057	10.86	0	0.495	0.716	-0.001	0.491	0.714
IL_C6.3 ENG_Column2 <- IL	0.68	0.679	0.046	14.83	0	0.583	0.761	-0.001	0.581	0.761
IL_C6.4 EMP_Column2 <- IL	0.749	0.747	0.043	17.5	0	0.655	0.822	-0.002	0.653	0.82
IL_C6.5 MOTI_Column2 <- IL	0.733	0.731	0.042	17.35	0	0.642	0.809	-0.002	0.641	0.808
IL_C6.6 REC_Column2 <- IL	0.649	0.649	0.049	13.37	0	0.549	0.739	0	0.545	0.736
IL_C6.7 FBAC_Column2 <- IL	0.801	0.802	0.024	33.86	0	0.754	0.845	0.001	0.75	0.843
IL_C6.8 ENER_Column2 <- IL	0.779	0.777	0.036	21.57	0	0.7	0.841	-0.002	0.698	0.84
IL_C6.9 INTGR_Column2 <- IL	0.749	0.747	0.036	20.53	0	0.671	0.814	-0.002	0.671	0.814
LMS_C3.1 DIV_Column2 <- LMS	0.669	0.666	0.048	13.86	0	0.564	0.751	-0.002	0.561	0.749
LMS_C3.10 CNTX_Column2 <- LMS	0.676	0.676	0.054	12.44	0	0.559	0.771	-0.001	0.554	0.767
LMS_C3.2 ENGA_Column2 <- LMS	0.662	0.66	0.056	11.72	0	0.54	0.759	-0.002	0.537	0.757
LMS_C3.3 PROV_Column2 <- LMS	0.674	0.673	0.049	13.76	0	0.569	0.763	-0.001	0.565	0.759
LMS_C3.4 IDEA_Column2 <- LMS	0.736	0.734	0.044	16.55	0	0.635	0.809	-0.003	0.631	0.806
LMS_C3.5 CAPT_Column2 <- LMS	0.785	0.783	0.033	23.6	0	0.711	0.839	-0.002	0.71	0.838
LMS_C3.6 SOL_Column2 <- LMS	0.724	0.722	0.043	16.83	0	0.631	0.798	-0.002	0.629	0.796
LMS_C3.7 CNSTR_Column2 <- LMS	0.785	0.785	0.033	24.11	0	0.715	0.843	0.001	0.707	0.838

	Bootstrapping results					Confidence intervals		Confidence intervals bias corrected		
	Sam-ple	Sample mean	Std dev.	*t* value	*p* value	2.50 %	97.50 %	Bias	2.50 %	97.50 %
LMS_C3.8 SPOT_Column2 <- LMS	0.729	0.73	0.034	21.37	0	0.659	0.792	0.001	0.653	0.788
LMS_C3.9 SHVAL_Column2 <- LMS	0.565	0.563	0.06	9.491	0	0.439	0.671	-0.002	0.436	0.669
Mkt <- SO	0.553	0.511	0.159	3.474	0.001	0.091	0.724	-0.042	0.167	0.739
Prod <- SO	0.632	0.593	0.128	4.942	0	0.25	0.751	-0.039	0.38	0.774
Rad <- SO	0.57	0.518	0.141	4.037	0	0.141	0.699	-0.052	0.324	0.728
SH_C2.1 TRUST_SH <- SHA	0.652	0.649	0.048	13.48	0	0.546	0.732	-0.003	0.546	0.732
SH_C2.2 UNDST_SH <- SHA	0.626	0.622	0.05	12.45	0	0.515	0.71	-0.004	0.516	0.711
SH_C2.3 SUPP_SH <- SHA	0.649	0.645	0.05	13.07	0	0.538	0.733	-0.004	0.538	0.733
SH_C2.4 RES_SH <- SHA	0.551	0.549	0.063	8.801	0	0.415	0.664	-0.001	0.41	0.66
SH_C2.5 IMAG_SH <- SHA	0.588	0.585	0.06	9.832	0	0.454	0.689	-0.003	0.448	0.686
SH_C2.6 TALNT_SH <- SHA	0.488	0.488	0.065	7.555	0	0.352	0.605	0	0.344	0.596
SH_C2.7 TENS_SH <- SHA	0.652	0.651	0.051	12.84	0	0.536	0.74	-0.001	0.531	0.737
SH_C2.8 GOV_SH <- SHA	0.759	0.758	0.033	23.2	0	0.689	0.817	-0.001	0.688	0.816
SH_C2.9 DESGN_SH <- SHA	0.538	0.532	0.068	7.896	0	0.385	0.654	-0.005	0.389	0.656
Sec <- SO	0.554	0.529	0.135	4.11	0	0.211	0.742	-0.025	0.267	0.757
Skil <- SO	0.603	0.583	0.13	4.62	0	0.312	0.783	-0.02	0.353	0.8
Sol <- SO	0.51	0.473	0.124	4.106	0	0.155	0.642	-0.037	0.269	0.66
TC_C1.1 CHNL_TC <- TC	0.685	0.682	0.048	14.18	0	0.57	0.762	-0.003	0.564	0.761
TC_C1.10 MODL_TC <- TC	0.728	0.724	0.043	16.85	0	0.629	0.798	-0.003	0.632	0.798
TC_C1.2 XPRT_TC <- TC	0.624	0.621	0.059	10.64	0	0.492	0.72	-0.003	0.483	0.718
TC_C1.3 TRCK_TC <- TC	0.65	0.644	0.057	11.47	0	0.519	0.742	-0.006	0.523	0.744
TC_C1.4 CRED_TC <- TC	0.466	0.466	0.071	6.544	0	0.315	0.589	0	0.303	0.585
TC_C1.5 NTIC_TC <- TC	0.478	0.479	0.066	7.186	0	0.341	0.6	0.001	0.335	0.594
TC_C1.6 OPP_TC <- TC	0.42	0.415	0.087	4.83	0	0.232	0.569	-0.005	0.23	0.568
TC_C1.7 PRTF_TC <- TC	0.497	0.493	0.074	6.714	0	0.336	0.623	-0.005	0.336	0.623
TC_C1.8 SGNL_TC <- TC	0.64	0.638	0.053	12.08	0	0.518	0.729	-0.001	0.51	0.724
TC_C1.9 PEST_TC <- TC	0.709	0.705	0.044	15.94	0	0.608	0.781	-0.004	0.611	0.782

	Bootstrapping results					Confidence intervals		Confidence intervals bias corrected		
	Sam-ple	Sample mean	Std dev.	*t* value	*p* value	2.50 %	97.50 %	Bias	2.50 %	97.50 %
VC_C4: 1 PROT_Column2 <- VC	0.464	0.462	0.07	6.621	0	0.318	0.587	-0.002	0.313	0.584
VC_C4: 10 COLAB_Column2 <- VC	0.676	0.675	0.048	14.2	0	0.571	0.759	-0.002	0.569	0.757
VC_C4: 2 PERC_Column2 <- VC	0.683	0.682	0.044	15.46	0	0.585	0.76	0	0.581	0.758
VC_C4: 3 SHFB_Column2 <- VC	0.702	0.701	0.047	14.95	0	0.601	0.782	-0.001	0.598	0.781
VC_C4: 4 DSTR_Column2 <- VC	0.694	0.694	0.04	17.19	0	0.607	0.765	-0.001	0.603	0.762
VC_C4: 5 SIMU_Column2 <- VC	0.715	0.713	0.038	19.03	0	0.633	0.781	-0.001	0.629	0.778
VC_C4: 6 CRIT_Column2 <- VC	0.626	0.622	0.055	11.34	0	0.506	0.721	-0.003	0.508	0.723
VC_C4: 7 IP_Column2 <- VC	0.587	0.584	0.052	11.38	0	0.472	0.678	-0.004	0.477	0.679
VC_C4: 8 TRLS_Column2 <- VC	0.704	0.702	0.041	17	0	0.614	0.777	-0.002	0.612	0.775
VC_C4: 9 COMM_Column2 <- VC	0.754	0.755	0.031	24.18	0	0.69	0.81	0.001	0.683	0.806
VR_C5.1 MKT_Column2 <- VR	0.604	0.601	0.054	11.26	0	0.485	0.695	-0.003	0.488	0.696
VR_C5.10 TSUPP_Column2 <- VR	0.683	0.683	0.043	15.85	0	0.591	0.761	0	0.584	0.756
VR_C5.2 HOLPR_Column2 <- VR	0.703	0.701	0.043	16.31	0	0.607	0.778	-0.002	0.602	0.774
VR_C5.3 MKTAL_Column2 <- VR	0.77	0.768	0.035	22.19	0	0.694	0.829	-0.002	0.69	0.828
VR_C5.4 FUD_Column2 <- VR	0.736	0.734	0.041	17.96	0	0.645	0.805	-0.002	0.643	0.804
VR_C5.5 AGIL_Column2 <- VR	0.694	0.693	0.043	16.14	0	0.602	0.77	-0.001	0.595	0.766
VR_C5.6 ECO_Column2 <- VR	0.736	0.736	0.034	21.55	0	0.663	0.797	0	0.659	0.795
VR_C5.7 TTRAN_Column2 <- VR	0.786	0.786	0.026	30.37	0	0.73	0.832	0	0.727	0.829
VR_C5.8 DEPL_Column2 <- VR	0.739	0.737	0.048	15.34	0	0.628	0.818	-0.002	0.625	0.815
VR_C5.9 PLTF_Column2 <- VR	0.709	0.708	0.046	15.34	0	0.607	0.787	-0.001	0.6	0.784
Ven <- SO	0.637	0.589	0.142	4.495	0	0.201	0.761	-0.048	0.339	0.787

Table K.2a: Outer loadings (CI) Part 1 of two parts

	Original Sample (O)	Sample Mean (M)	2.50%	97.50%	Significantf rom CI	p-value from T-test
Integrative leader->IL_C6.1 ROLE_Column2	0.478	0.475	0.336	0.601	yes	0.00
Integrative leader->IL_C6.10 FWRK_Column2	0.67	0.669	0.563	0.755	yes	0.00
Integrative leader->IL_C6.11 OWN_Column2	0.737	0.736	0.633	0.812	yes	0.00
Integrative leader->IL_C6.2 VIS_Column2	0.615	0.613	0.494	0.708	yes	0.00
Integrative leader->IL_C6.3 ENG_Column2	0.68	0.68	0.588	0.768	yes	0.00
Integrative leader->IL_C6.4 EMP_Column2	0.749	0.746	0.651	0.818	yes	0.00
Integrative leader->IL_C6.5 MOTI_Column2	0.733	0.73	0.641	0.8	yes	0.00
Integrative leader->IL_C6.6 REC_Column2	0.649	0.65	0.553	0.736	yes	0.00
Integrative leader->IL_C6.7 FBAC_Column2	0.801	0.802	0.749	0.848	yes	0.00
Integrative leader->IL_C6.8 ENER_Column2	0.779	0.777	0.7	0.84	yes	0.00
Integrative leader->IL_C6.9 INTGR_Column2	0.749	0.745	0.667	0.812	yes	0.00
Liberate mind sets->LMS_C3.1 DIV_Column2	0.669	0.669	0.569	0.754	yes	0.00
Liberate mind sets->LMS_C3.10 CNTX_Column2	0.676	0.676	0.56	0.774	yes	0.00
Liberate mind sets->LMS_C3.2 ENGA_Column2	0.662	0.658	0.53	0.761	yes	0.00
Liberate mind sets->LMS_C3.3 PROV_Column2	0.674	0.67	0.568	0.754	yes	0.00
Liberate mind sets->LMS_C3.4 IDEA_Column2	0.736	0.733	0.641	0.808	yes	0.00
Liberate mind sets->LMS_C3.5 CAPT_Column2	0.785	0.784	0.708	0.843	yes	0.00
Liberate mind sets->LMS_C3.6 SOL_Column2	0.724	0.722	0.633	0.793	yes	0.00
Liberate mind sets->LMS_C3.7 CNSTR_Column2	0.785	0.785	0.717	0.84	yes	0.00
Liberate mind sets->LMS_C3.8 SPOT_Column2	0.729	0.731	0.658	0.792	yes	0.00
Liberate mind sets->LMS_C3.9 SHVAL_Column2	0.565	0.561	0.438	0.67	yes	0.00
Stake-holders alignment->SH_C2.1 TRUST_SH	0.652	0.648	0.548	0.731	yes	0.00
Stake-holders alignment->SH_C2.2 UNDST_SH	0.626	0.623	0.513	0.709	yes	0.00
Stake-holders alignment->SH_C2.3 SUPP_SH	0.649	0.646	0.536	0.736	yes	0.00
Stake-holders alignment->SH_C2.4 RES_SH	0.551	0.549	0.41	0.654	yes	0.00
Stake-holders alignment->SH_C2.5 IMAG_SH	0.588	0.588	0.457	0.696	yes	0.00
Stake-holders alignment->SH_C2.6 TALNT_SH	0.488	0.487	0.349	0.603	yes	0.00
Stake-holders alignment->SH_C2.7 TENS_SH	0.652	0.654	0.55	0.74	yes	0.00
Stake-holders alignment->SH_C2.8 GOV_SH	0.759	0.759	0.687	0.814	yes	0.00
Stake-holders alignment->SH_C2.9 DESGN_SH	0.538	0.538	0.396	0.657	yes	0.00
Success orientation->Fin	0.542	0.491	0.046	0.69	yes	0.00
Success orientation->Func	0.648	0.628	0.391	0.794	yes	0.00

Table K.2b: Outer loadings (CI) Part 2 of two parts

	Original Sample (O)	Sample Mean (M)	2.50%	97.50%	Significantf rom CI	p-value from T-test
Success orientation->Hint	0.639	0.599	0.296	0.74	yes	0.00
Success orientation->Mkt	0.553	0.512	0.064	0.718	yes	0.00
Success orientation->Prod	0.632	0.596	0.285	0.745	yes	0.00
Success orientation->Rad	0.57	0.526	0.172	0.701	yes	0.00
Success orientation->Sec	0.554	0.534	0.216	0.742	yes	0.00
Success orientation->Skil	0.603	0.581	0.298	0.782	yes	0.00
Success orientation->Sol	0.51	0.482	0.172	0.645	yes	0.00
Success orientation->Ven	0.637	0.594	0.21	0.767	yes	0.00
Techno-Connectedness->TC_C1.1 CHNL_TC	0.685	0.681	0.571	0.759	yes	0.00
Techno-Connectedness->TC_C1.10 MODL_TC	0.728	0.724	0.621	0.805	yes	0.00
Techno-Connectedness->TC_C1.2 XPRT_TC	0.624	0.624	0.491	0.725	yes	0.00
Techno-Connectedness->TC_C1.3 TRCK_TC	0.65	0.645	0.523	0.742	yes	0.00
Techno-Connectedness->TC_C1.4 CRED_TC	0.466	0.465	0.31	0.586	yes	0.00
Techno-Connectedness->TC_C1.5 NTIC_TC	0.478	0.476	0.345	0.601	yes	0.00
Techno-Connectedness->TC_C1.6 OPP_TC	0.42	0.418	0.231	0.578	yes	0.00
Techno-Connectedness->TC_C1.7 PRTF_TC	0.497	0.494	0.346	0.624	yes	0.00
Techno-Connectedness->TC_C1.8 SGNL_TC	0.64	0.64	0.526	0.738	yes	0.00
Techno-Connectedness->TC_C1.9 PEST_TC	0.709	0.708	0.62	0.783	yes	0.00
Value Creation->VC_C4: 1 PROT_Column2	0.464	0.464	0.321	0.595	yes	0.00
Value Creation->VC_C4: 10 COLAB_Column2	0.676	0.676	0.573	0.759	yes	0.00
Value Creation->VC_C4: 2 PERC_Column2	0.683	0.685	0.587	0.763	yes	0.00
Value Creation->VC_C4: 3 SHFB_Column2	0.702	0.7	0.603	0.785	yes	0.00
Value Creation->VC_C4: 4 DSTR_Column2	0.695	0.693	0.603	0.762	yes	0.00
Value Creation->VC_C4: 5 SIMU_Column2	0.715	0.714	0.635	0.782	yes	0.00
Value Creation->VC_C4: 6 CRIT_Column2	0.626	0.625	0.51	0.72	yes	0.00
Value Creation->VC_C4: 7 IP_Column2	0.587	0.586	0.481	0.679	yes	0.00
Value Creation->VC_C4: 8 TRLS_Column2	0.704	0.7	0.607	0.775	yes	0.00
Value Creation->VC_C4: 9 COMM_Column2	0.754	0.756	0.686	0.809	yes	0.00
Value Realisation->VR_C5.1 MKT_Column2	0.605	0.604	0.486	0.698	yes	0.00
Value Realisation->VR_C5.10 TSUPP_Column2	0.683	0.68	0.587	0.76	yes	0.00
Value Realisation->VR_C5.2 HOLPR_Column2	0.704	0.704	0.611	0.781	yes	0.00
Value Realisation->VR_C5.3 MKTAL_Column2	0.77	0.769	0.691	0.829	yes	0.00
Value Realisation->VR_C5.4 FUD_Column2	0.736	0.734	0.654	0.806	yes	0.00
Value Realisation->VR_C5.5 AGIL_Column2	0.694	0.691	0.591	0.769	yes	0.00
Value Realisation->VR_C5.6 ECO_Column2	0.736	0.735	0.666	0.797	yes	0.00
Value Realisation->VR_C5.7 TTRAN_Column2	0.786	0.785	0.726	0.832	yes	0.00
Value Realisation->VR_C5.8 DEPL_Column2	0.739	0.741	0.629	0.823	yes	0.00
Value Realisation->VR_C5.9 PLTF_Column2	0.709	0.709	0.597	0.787	yes	0.00

Table K.3: Cross loadings from SmartPLS-SEM

	IL	LMS	SHA	SO	TC	VC	VR
Fin	0.061	-0.003	0.173	0.542	0.153	0.173	0.21
Func	0.217	0.147	0.21	0.648	0.298	0.21	0.233
Hint	0.126	0.245	0.226	0.639	0.216	0.153	0.213
IL_C6.1 ROLE_Column2	0.478	0.344	0.286	0.108	0.325	0.332	0.233
IL_C6.10 FWRK_Column2	0.67	0.492	0.358	0.177	0.419	0.535	0.53
IL_C6.11 OWN_Column2	0.737	0.508	0.431	0.209	0.294	0.471	0.511
IL_C6.2 VIS_Column2	0.615	0.343	0.426	0.194	0.313	0.429	0.357
IL_C6.3 ENG_Column2	0.68	0.438	0.471	0.155	0.432	0.458	0.383
IL_C6.4 EMP_Column2	0.749	0.451	0.421	0.192	0.362	0.45	0.353
IL_C6.5 MOTI_Column2	0.733	0.456	0.386	0.127	0.291	0.361	0.378
IL_C6.6 REC_Column2	0.649	0.462	0.384	0.097	0.379	0.527	0.494
IL_C6.7 FBAC_Column2	0.801	0.559	0.482	0.133	0.448	0.576	0.509
IL_C6.8 ENER_Column2	0.779	0.565	0.42	0.17	0.366	0.512	0.438
IL_C6.9 INTGR_Column2	0.749	0.514	0.361	0.298	0.403	0.506	0.558
LMS_C3.1 DIV_Column2	0.438	0.669	0.292	0.208	0.359	0.395	0.39
LMS_C3.10 CNTX_Column2	0.502	0.676	0.378	0.132	0.393	0.504	0.391
LMS_C3.2 ENGA_Column2	0.436	0.662	0.346	0.076	0.302	0.384	0.288
LMS_C3.3 PROV_Column2	0.455	0.674	0.232	0.161	0.329	0.334	0.282
LMS_C3.4 IDEA_Column2	0.465	0.736	0.284	0.195	0.353	0.42	0.331
LMS_C3.5 CAPT_Column2	0.514	0.785	0.44	0.199	0.469	0.491	0.442
LMS_C3.6 SOL_Column2	0.478	0.724	0.405	0.242	0.465	0.528	0.439
LMS_C3.7 CNSTR_Column2	0.564	0.785	0.43	0.233	0.417	0.51	0.448
LMS_C3.8 SPOT_Column2	0.487	0.729	0.345	0.271	0.397	0.494	0.437
LMS_C3.9 SHVAL_Column2	0.375	0.565	0.246	0.042	0.261	0.345	0.29
Mkt	0.133	0.063	0.15	0.553	0.125	0.116	0.183
Prod	0.126	0.244	0.219	0.632	0.305	0.166	0.223
Rad	0.063	0.078	0.191	0.57	0.15	0.156	0.175
SH_C2.1 TRUST_SH	0.343	0.242	0.652	0.161	0.392	0.361	0.276
SH_C2.2 UNDST_SH	0.365	0.255	0.626	0.157	0.332	0.318	0.362
SH_C2.3 SUPP_SH	0.33	0.244	0.649	0.233	0.372	0.352	0.381
SH_C2.4 RES_SH	0.308	0.2	0.551	0.233	0.274	0.386	0.404
SH_C2.5 IMAG_SH	0.375	0.361	0.588	0.202	0.377	0.408	0.338
SH_C2.6 TALNT_SH	0.315	0.33	0.488	0.218	0.214	0.368	0.311
SH_C2.7 TENS_SH	0.361	0.365	0.652	0.088	0.424	0.413	0.29
SH_C2.8 GOV_SH	0.487	0.408	0.759	0.27	0.399	0.491	0.475
SH_C2.9 DESGN_SH	0.254	0.265	0.538	0.126	0.353	0.266	0.242

	IL	LMS	SHA	SO	TC	VC	VR
Sec	0.158	0.169	0.183	0.554	0.22	0.16	0.215
Skil	0.182	0.212	0.221	0.603	0.224	0.13	0.193
Sol	0.079	0.11	0.098	0.51	0.263	0.124	0.166
TC_C1.1 CHNL_TC	0.369	0.314	0.339	0.304	0.685	0.379	0.312
TC_C1.10 MODL_TC	0.347	0.434	0.426	0.173	0.728	0.382	0.321
TC_C1.2 XPRT_TC	0.378	0.296	0.336	0.311	0.624	0.297	0.224
TC_C1.3 TRCK_TC	0.303	0.281	0.286	0.2	0.65	0.362	0.32
TC_C1.4 CRED_TC	0.235	0.27	0.322	0.193	0.466	0.234	0.139
TC_C1.5 NTIC_TC	0.317	0.332	0.32	0.216	0.478	0.228	0.233
TC_C1.6 OPP_TC	0.216	0.16	0.308	0.154	0.42	0.178	0.153
TC_C1.7 PRTF_TC	0.26	0.286	0.362	0.169	0.497	0.291	0.299
TC_C1.8 SGNL_TC	0.35	0.377	0.329	0.195	0.64	0.302	0.23
TC_C1.9 PEST_TC	0.323	0.413	0.386	0.222	0.709	0.386	0.359
VC_C4: 10 COLAB_Column2	0.448	0.397	0.39	0.214	0.347	0.676	0.556
VC_C4: 2 PERC_Column2	0.467	0.454	0.476	0.171	0.375	0.683	0.534
VC_C4: 3 SHFB_Column2	0.487	0.352	0.505	0.221	0.419	0.702	0.503
VC_C4: 4 DSTR_Column2	0.494	0.501	0.366	0.149	0.431	0.694	0.456
VC_C4: 5 SIMU_Column2	0.498	0.468	0.406	0.126	0.402	0.715	0.566
VC_C4: 6 CRIT_Column2	0.391	0.462	0.376	0.056	0.368	0.626	0.43
VC_C4: 7 IP_Column2	0.331	0.258	0.332	0.238	0.323	0.587	0.446
VC_C4: 8 TRLS_Column2	0.483	0.496	0.414	0.164	0.295	0.704	0.558
VC_C4: 9 COMM_Column2	0.538	0.493	0.496	0.272	0.325	0.754	0.568
VR_C5.1 MKT_Column2	0.329	0.201	0.323	0.2	0.19	0.501	0.604
VR_C5.10 TSUPP_Column2	0.484	0.484	0.399	0.235	0.369	0.551	0.683
VR_C5.2 HOLPR_Column2	0.472	0.383	0.421	0.183	0.31	0.584	0.703
VR_C5.3 MKTAL_Column2	0.475	0.366	0.361	0.279	0.345	0.511	0.77
VR_C5.4 FUD_Column2	0.422	0.352	0.356	0.239	0.322	0.465	0.736
VR_C5.5 AGIL_Column2	0.45	0.323	0.383	0.137	0.233	0.509	0.694
VR_C5.6 ECO_Column2	0.48	0.424	0.453	0.361	0.295	0.529	0.736
VR_C5.7 TTRAN_Column2	0.53	0.445	0.486	0.215	0.362	0.6	0.786
VR_C5.8 DEPL_Column2	0.382	0.443	0.393	0.28	0.314	0.558	0.739
VR_C5.9 PLTF_Column2	0.439	0.38	0.437	0.266	0.377	0.557	0.709
Ven	0.136	0.114	0.111	0.637	0.126	0.121	0.147

APPENDIX L:

TECHNOLOGY INNOVATION LEADER COMPETENCIES FROM PRACTITIONER WORKSHOP

Cluster	Competence
Connected with evolving technology innovation landscape	Familiar with latest technology trends and cutting-edge technology
	Have vision on where bioscience technologies/global landscape are heading and general knowledge of adjacent fields
	Knowledgeable in all fields where the team/unit is focusing
	Find and integrate trends in selected fields of endeavour
	Acknowledged/respected/ well known in their field of science (external and team)
	Thought leader and able to talk about field with authority
	Expert or at least upcoming expert
	Relevant experience as both administrator and life scientist (lab and industry)
	Track record in academia and/or institutions dedicated to bio-research.
	Understanding the research field (in depth)
	As high as possible accomplished in academic domain, ideally PhD but not vital
	Well published in reputable journals
	Participate in high level forums/ conferences/ congresses
	Track record in review of journals
	External examiner for higher education
	Invited to review panels
	International project participation (include hypothesis-driven research)
Stakeholder alignment and support	Ability to collaborate with multiple current and prospective stakeholders/clients
	Networked with domain experts/leaders
	Networks in SA, region and international
	Stakeholder experience and understanding
	Be in touch with multiple stakeholders who have sway on the outcomes and direction of the technology
	Client, partner and broader stakeholder management
	Understand stakeholders and market needs and demand of technology
	Aware of own competencies/ relevance to market needs
	Able to attract/secure funding from stakeholders to address research challenges within and across fields
	Able to find collaborative opportunities/partnerships
	Effective resourcing of people/skills and infrastructure
	Partnering and collaboration at all levels (local/international science institutions, companies, universities, clients)

Cluster	Competence
Liberate mindsets/ shift paradigms	Open to new inputs
	Strategic thinking and foresight for longer-term competitive advantage
	Use networks' inputs to guide research
	Collaborate where unit lacks skills (local and international)
	Multi-disciplinary approach
	Show interest in areas beyond own expertise area
	Able to look beyond own area of expertise for insights to take unit forward
	Able to think "outside the box"
	Knowledge of the science behind the technology
	Able to connect science to technology offerings and the market place
Value creation	Develop new/novel technology (rather than adopting other people's innovations)
	High-impact output
Value realisation	Able to map paths for transfer of technology to market via self or associated paths
	Able to translate lab-scale work to larger-scale application
Integrative leadership	Role-model/setting the example in areas like dedicated work ethics, innovation thinking/orientation, lead from front (labs)
	Clear vision and plan to meet the vision and mission of the CSIR/goals
	Provide in consultation with the team strong direction; leapfrog the team forward
	High emotional intelligence
	Leadership track record
	Integrity that will not be easily influenced by ideas of close colleagues or 'buddies'
	Able to make decisions and takes accountability for decisions
	Can encourage/motivate/ inspire others via enthusiasm & drive towards common vision/goals/relevant outputs
	People management skills
	Can work with researchers diplomatically
	Lead and manage scientists
	Grow and support each individual in the team to his/her optimal research abilities, outputs and contribution
	Able to manage science laboratories
	Able to manage projects
	Conflict management
	Convincing speaker/communicator

Cluster	Competence
(Integrative skills)	Integrative competence (multi-discipline, multi-organisation, market/technology)
	Integrate activities between groups and their activities
	Integrate innovation across fields (core and adjoining)
	Able to pull in different skill sets to achieve different technology innovations
	The more senior the leader the wider the integration should be effected
	Change management (coping with constant change and able to apply expertise from and in other fields)
	Able to deliver through teams
(Business skills)	Access and process business intelligence
	Market to technology; technology to market
	Provide business leadership
	Ensure high visibility of research area
	Business development
	Exploit opportunities to sell our skills and competencies to generate income
	Negotiation
	Financial management (including unit practices with reference to calculating and recovering costs)