

# **NATIONAL INNOVATION SYSTEM: SOUTH AFRICA & CHINA COMPARED**

**Haoyi Zhang**



**Supervisor: Prof CSL Schutte**

**Faculty of Engineering**

**Department of Industrial Engineering**

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## **I. Declaration**

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## II. Abstract

The concept of National Innovation System (NIS) as new conceptual framework appeared in the late 1980s. The framework of NIS not only focuses on the science and technology development of a country, but also on concerns about a nation's demand and strategy.

The best technology, as well as patents, can be found in developed countries. Their development leads world development in many ways and influences the development model in developing countries. Although it is not hard to see that they seem to be progressing well, the question is why development just happens in some countries. Even fast developing countries, like China, India, Brazil, and South Africa have fewer such well-known or successful business models, compared to developed countries. The thesis attempts to scrutinise the internal and external factors in NIS which may influence countries and the innovation of enterprises within South Africa and China.

The thesis focuses on fundamental research of the NIS of South Africa and China. The objective of the thesis is to find out which factors are involved in the NIS and how the system works in South Africa and China. The purpose of the study is to ascertain the difference and gap between these two countries and other more innovative countries, as well as the differences between South Africa and China. The literature study and quantitative method will be used to research and compare the NIS of South Africa and China.

### III. Opsomming

Die konsep van Nasionale Innovasie Stelsels (NIS) as 'n nuwe konsepionele raamwerk het in die laat 1980s na vore gekom. Die raamwerk van NIS het beide op die wetenskap en tegnologiese ontwikkeling, asook nasionale strategie van 'n land gefokus.

Die beste tegnologie sowel as patentregte kan in ontwikkelde lande gevind word. Hul bydrae is aan die voor front van globale ontwikkeling en het 'n direkte invloed op ontwikkelingsmodelle vir ander ontwikkelende lande. Die voorspoed in hierdie lande is vir almal duidelik, maar die vraag is waarom ontwikkeling slegs plaasvind in sommige lande. Lande soos China, Indië, Brasilië en Suid Afrika het minder goeie en suksesvolle besigheidsmodelle, in vergelyking met ontwikkelde lande, alhoewel ontwikkeling steeds vinnig plaasvind. Die tesis poog om interne en eksterne faktore van die NIS te ontleed wat sal bydra tot die innovasie van ondernemingsontwikkeling in Suid Afrika en China.

Die tesis fokus op fundamentele navorsing op die NIS van Suid Afrika en China. Die doel van die tesis is om uit te vind watter faktore die NIS in beide Suid Afrika en China beïnvloed. Die besondere oogmerk van die studie is om verskille en gapings tussen die twee lande en ander innovasie georiënteerde lande te beklemtoon, asook die verskil tussen Suid Afrika en China. Die literatuurstudie en kwantitatiewe metode word geïmplementeer om die NIS in Suid Afrika en China te ondersoek en vergelyk.

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## VIII. Glossary

AAAS	The American Association for the Advancement of Science
ARC	Agricultural Research Council
BEE	Black Economic Empowerment
BRICS	Brazil, Russia, India, China and South Africa
CAE	Chinese Academy of Engineering
CAS	Chinese Academy of Sciences
CAV	The Centurion Aerospace Village
CGS	Council of Geoscience
CIPC	Companies and Intellectual Property Commission
CSIR	Council for Scientific and Industrial Research
EPO	European Patent Office
ESASTAP	European-South African Science and Technology Advancement Programme
FTE	Full-time Equivalent
GDP	Gross Domestic Product
GRI	Governmental Research Institutes
HE	Higher Education
HR	Human Resources
HSRC	Human Sciences Research Council
IBSA	The India-Brazil-South Africa Alliance
IFCO	Innovation Fund Commercialisation Office
INSITE	The International Science Innovation & Technology Expo

IP	Intellectual Property
JCR	Journal Citation Reports
MRC	Medical Research Council
NACI	National Advisory Council on Innovation
NIS	National Innovation System
NSF	National Science Foundation
OECD	The Organisation for Economic Co-operation and Development
OSTP	The Office of Science and Technology Policy
R&D	Research and Development
S&T	Science and Technology
SABS	South African Bureau of Standards
SARIMA	The Southern African Research & Innovation Management Association
SBIR	The Small Business Innovation Research
SME	Small and Medium Enterprises
SMME	Small, Medium and Micro Enterprises
STTR	The Small Business Technology Transfer Programme
TEKES	The Finnish Funding Agency for Technology and Innovation (Teknologian ja Innovaatioiden Kehittämiskeskus)
THRIP	The Technology and Human Resources for Industry Programme
TTO	Technology Transfer Office
UN	United Nations
USPTO	The US Patent and Trademark Office
VTT	Technical Research Centre of Finland (Valtion Teknillinen Tutkimuskeskus)

# 1. Introduction

This chapter provides the introductory sections of the thesis, which include the problem statement, target of this research, research background and hypothesis. The methodology will also be established.



## 1.1 Objective

This thesis focuses on fundamental research of the National Innovation Systems (NIS) of South Africa and China. The objective of the thesis is to find out which factors are involved in the national innovation system and how the system works in South Africa and China. The purpose of the study is further to ascertain the difference and gap between these two countries and other more innovative countries, as well as the differences between South Africa and China. Some recommendations will be made at the end of the study.

The objectives of the research are:

- To determine the obvious view of major drivers of change in the system, as well as to evaluate how well they are addressed in the innovation policy.
- To identify ways of addressing the current and future challenges.
- To point out any needs for institutional and policy adjustments and reforms.
- To classify and identify the advantages and disadvantages in the NIS.
- To draw conclusions and form recommendations for policy governance and steering concerning the NIS of each country.

## 1.2 Background

South Africa is now a member of BRICS, a grouping acronym referring to an economic organisation which consists of Brazil, Russia, India, China and South Africa and which joined in 2010. The question arises whether the South African economy will also display the growth potential of the other BRICS countries. There is widespread doubt about this. However, as the most competitive country in sub-Saharan Africa, South Africa has its own development model. Nowadays, its position as the No.1 power in Africa is being challenged. South Africa experiences considerable domestic, as well as international pressure. The strategy of how to keep the country growing while still being competitive in the world is a critical concern of the government of South Africa. This thesis would like to find out what kind of role NIS plays.

China, as one of the fastest developing countries, has many typical modern innovation experiences and has a wealth of advantages. These include a huge, adaptable population with an affinity for improvisation and reverse engineering which refers to the technology plagiarism, low-cost labour, operations and overheads, as well as mature industrial clusters ready to supply a variety of parts and components. These elements create a strong culture of innovation, one that companies from developed economies soon will either profit from, or compete against, as China moves beyond labour-intensive, low-value-added consumer goods.

## **1.3 Research Methodology**

To build up a framework for researching and comparing the NIS of South Africa and China, a methodology will be introduced in this chapter. Simultaneously, this section will also figure out the problem statement, hypothesis, research questions and domain of this study.

### **1.3.1 Problem Statement**

The purpose of the research is to determine the difference and gap between South Africa and China on the one hand and other more innovative countries, as well as the differences between South Africa and China.

The best technology, as well as patents, can be found in developed countries. Their development leads world development in many ways and influences the development model in developing countries. Although it is not hard to see that they seem to be progressing well, the question is why development just happens in some countries. Even fast developing countries, like China, India, Brazil, South Africa and a few more, have much less such well-known or successful business models, compared to developed countries. The thesis attempts to scrutinise the internal and external factors in National Innovation Systems which may influence countries and the innovation of enterprises within South Africa and China.

### 1.3.2 Research Hypothesis and Research Questions

The aim of the evaluation of NIS is to provide insights into how the National Innovation System, its structure and organisation can respond to the changes in the global environment and to the challenges these changes pose.

The hypothesis of this thesis is

**“By documenting the characteristics of the National Innovation Systems of China and South Africa for identified criteria, it is possible to understand the differences and identify strengths, opportunities, weaknesses and threats.”**

All the main characteristics of each country are normally major issues and the bottleneck of their economy as well. The factors have to be analysed particularly. This thesis will highlight the fact that China and South Africa, as two developing countries, can learn from and probably be just as good as Finland and the US, who have been classified as showcase examples for successful National Innovation Systems.

The research questions that have to be answered during the research process to support the above hypothesis are:

1. Which criteria must be used to identify the characteristics of a NIS?
2. In terms of these criteria, what are the main differences between South Africa and China?
3. What are the advantages and disadvantages of the NIS in South Africa and China?
4. Which collaborative opportunities exist between South Africa and China in the innovation field?
5. What can South Africa and China do to improve their NIS?

### 1.3.3 Research Method

To answer the questions above, a proper methodology needed to be planned. The thesis will basically concentrate on five procedures before the conclusion will be made.

The main parts are the following:

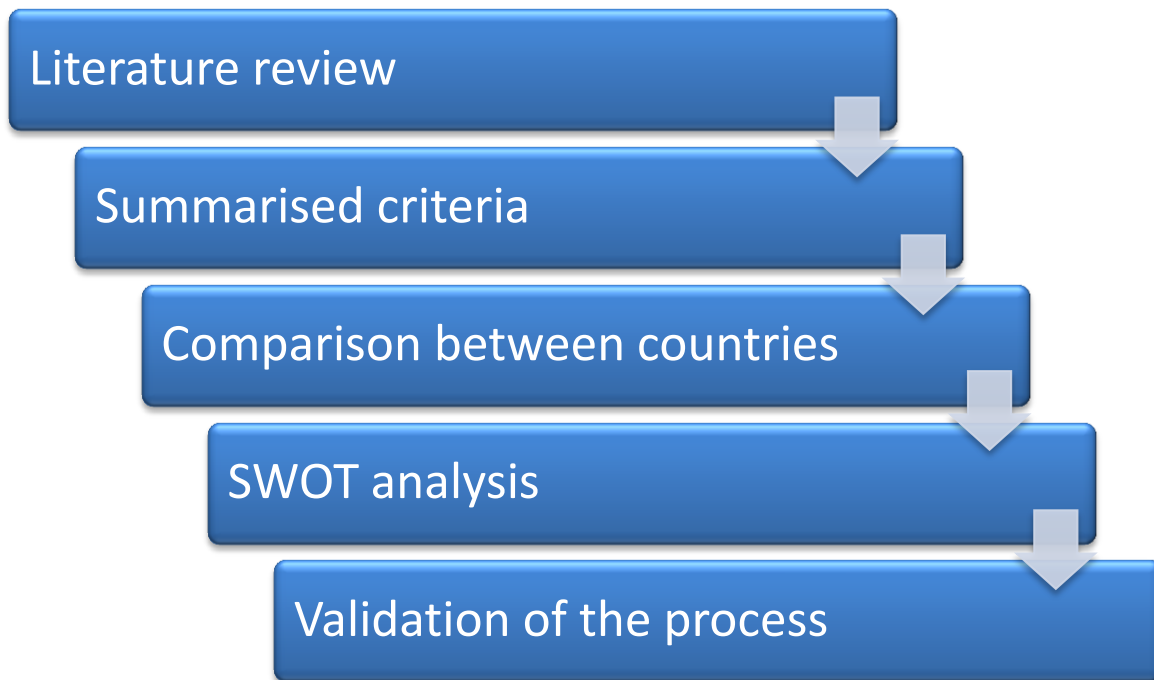


Figure 1.1 Study Flow

Firstly, a domain literature research, in which the targeted research domains have to be introduced.

Secondly, criteria will be summarised from the above literature studies that illustrate research into National Innovation Systems and the comparisons of NIS among nations. The reason for this is because the definition, which will be mentioned in the next chapter, is not clear enough to be a benchmark to evaluate the standard of NIS. Through the pre-study of other research, it is not difficult to see that the understanding of National Innovation Systems in different countries is dissimilar. Consequently there seems to be no mutual standard for the following comparison.

What needs to be done in this section is to try to gather criteria or factors which are used frequently in other research studies and which may have a massive influence on a NIS.

The differences between developed and developing countries have to be classified. For instance, many developed countries are faced with stagnating or declining populations, and therefore labour inputs and investments in physical capital are facing diminishing returns.

China, on the contrary, is totally the opposite. The major difference for South Africa is the gap between the rich and the poor. South Africa has the highest Gini-coefficient index, reaching 0.70% in 2008, which means quite a sharp rise. In rich countries the figure is closer to 0.3 and the world's most unequal region, Latin America, has a Gini-coefficient of around 0.5 (May, 2010) .

Thirdly, the summarised criteria will be used as a benchmark. Countries will be horizontally compared, using all these factors. In the end, a summary will be given to show the difference between the countries being compared.

After that, a SWOT analysis will be used to analyse the advantages and disadvantages, according to the information that has been given in the comparison. The result will cover the main characteristics of the South African and Chinese Innovation Systems and show similarities and differences.

The last step of the process will be to verify that the research covers all the questions and to conclude the logical loop.

#### **1.3.4 Domain Research**

The NIS approach was applied to regions, sectors or nations to describe and explain the structure of the main factors involved in innovation processes. Through understanding these factors, governments could accelerate economic productivity and increase the national rate of growth in wealth, and even personal incomes. The approach required in the application or expansion of the theory should therefore be based on some form of logic or structure.

During this part, the objective of this research will be reasoned. In order to compare two countries' National Innovation Systems, the methodology will be investigated and determined.

### **1.4 Document Layout Structure**

The layout and order of this research is presented as a logical flow. The following table presents the relationship of the research method and the document structure.

	Literature Review	Summarised Criteria	Comparison	SWOT Analysis	Validate Process
Chapter 1	✓				
Chapter 2	✓				
Chapter 3	✓	✓			
Chapter 4	✓	✓	✓		
Chapter 5				✓	
Chapter 6					✓
Chapter 7					✓

Figure 1.2 Research Document Layout

The following is a short description of the document structure and chapter content:

Chapter 1 provides the introductory sections of the thesis, which include the problem statement, target of this research, research background and hypothesis. The methodology will also be established.

Chapter 2 presents the knowledge background for the following research. It provides the definitions of innovation, which will be referenced, and the National Innovation System. In this chapter, an introduction of the Fugle module will also be presented as the progress of innovation research in the institute.

Chapter 3 illustrates how the National Innovation System between and among nations is compared and identifies the criteria which have been summarised from other NIS reports and literature and of NIS comparisons which helped to establish focus needs during the research process.

This chapter explains the process of criteria analysis for future comparison. Firstly, the method of identifying the countries, which will be used in the comparison, is introduced after which the method will be introduced. Then all the criteria will be defined after a cluster of literature studies.

Chapter 4 shows the process of comparison between Finland, USA, South Africa and China. It uses the criteria that are summarised in Chapter 3 to analyse the situation of NIS in each country. Most of the literature studies in this chapter are basically from local researchers who are trying to make sure all of them are objective and honest.

Chapter 5 uses a SWOT method to analyse the NIS of South Africa and China. The purpose of this chapter is to use the information given in Chapter 4 to demonstrate the final analysis and a conclusion of the situation of NIS in South Africa and China.

It also gives the advantages and disadvantages of NIS in South Africa and China, and tries to identify opportunities for collaboration between them.

Chapter 6 verifies the research process of this thesis. It validates the methodology, criteria and analysis process.

The validation also uses an interview method to verify that the thesis, criteria and research methodology sufficiently address the status of the NIS in South Africa and China.

Chapter 7 presents a conclusion of the methodology process and summarises the research result, as well as the results obtained from validation.

The final section of the chapter highlights certain focus areas that may provide possible opportunities for future related research.

## **1.5 Chapter Conclusion**

Chapter 1 has provided the background of the thesis as well as the general idea of the methodology. It also pointed out the object of the study and also how the document layout structure would be.

The purpose of this chapter is to present the thesis methodology and structure for the future study. Chapter 2 gives the background knowledge that the study may need to research NIS.

## **2. Fundamentals of NIS**

This chapter presents the knowledge background to be able to do the research. It provides the definitions, which will be referenced, of innovation and National Innovation Systems. In this chapter, an introduction of the Fugle module will also be presented as the latest progress of innovation research.



## 2.1 What is Innovation?

Innovation describes something new in the history of economic development. The word “innovation” is derived from the Latin word “*innovatus*”, meaning to renew or change (Wikipedia). However, the essence of innovation is not merely being new, but also usually something that is novel and different. The content of innovation is described as below:

- 1) The introduction of new products — that is products with which consumers are not yet familiar — or products of a new quality.
- 2) The introduction of a new method of production, which needs by no means to be founded upon a scientifically new discovery, but can also exist in a new way of handling a commodity commercially.
- 3) The opening of a new market, into which the particular branch of manufacture of the country in question has not previously entered, whether or not this market has existed before.
- 4) The conquest of a new source of supply of raw materials or half-manufactured goods, again irrespective of whether this source already exists or whether it has first to be created.
- 5) The carrying out of the new organisation of any industry, like the creation of a monopoly position or the breaking up of a monopoly position.

(Schumpeter, 1934)

From the definitions of innovation, it becomes clear that it is closely linked to invention. Invention actually forms part of the process of innovation, which means innovation therefore includes not only invention, but also activities that facilitate the introduction of new or improved products or services onto the market. Innovation also means exploiting new technology and employing out-of-the-box thinking to generate new value and to bring about significant changes in society.

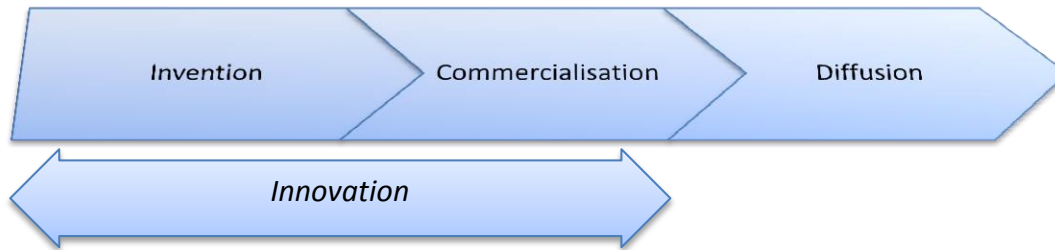


Figure 2.1 Innovation Process

Figure 2.1 clearly shows that both invention and commercialisation taken together make up innovation. The topic to be discussed, of the National Innovation System focuses more on the commercialisation part, but it also emphasises how guidance of national policies and governmental facilities could help enterprises operate sustainably. This means that a system should be used to guide enterprises to commercialise their products or services. While diffusion is also part of what is going to be discussed in the research, it needs to be said that it is not part of innovation, but is closely associated with NIS.

Innovation has been defined as four major types: product innovation, process innovation, marketing innovation and organisational innovation.

- Product innovation: A product or service that is new or significantly improved. This includes significant improvements in technical specifications, components and materials, software products, user friendliness or other functional characteristics.
- Process innovation: A new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software.
- Marketing innovation: A new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.
- Organisational innovation: A new organisational method in business practices, workplace organisation or external relations. (OECD, 2005)

Innovation, apparently, is a complex topic that runs not only with simple academic disciplines, including engineering, financial or economic, but also different fields of professional expertise. The process of innovation will help accelerate economic recovery and put countries back on the path of sustainable and greener development.

The innovation module process has developed for 7 generations from a simply linear process to increasingly complex interactive open models (refer to Table 2.1).

Model	Generation	Characteristic
Technology Push	First	Simple linear sequential process, emphasis on R&D and science.
Market Pull	Second	Simple linear sequential process, emphasis on marketing, the market is the source of new ideas for R&D
Coupling Model	Third	Recognising interaction between different elements and feedback loops between them, emphasis on integrating R&D and marketing
Interactive Model	Fourth	Combinations of push and pull models, integration within firms and the emphasis on external linkages
Network Model	Fifth	Emphasis on knowledge accumulation and external linkages, systems integration and extensive networking
Open Model	Sixth	Internal and external ideas, as well as, internal and external paths to market can be combined to advance the development of new technologies
Fugle Model	Seventh	Combines the convergent innovation front-end or funnels with the divergent deployment and exploitation of the innovation

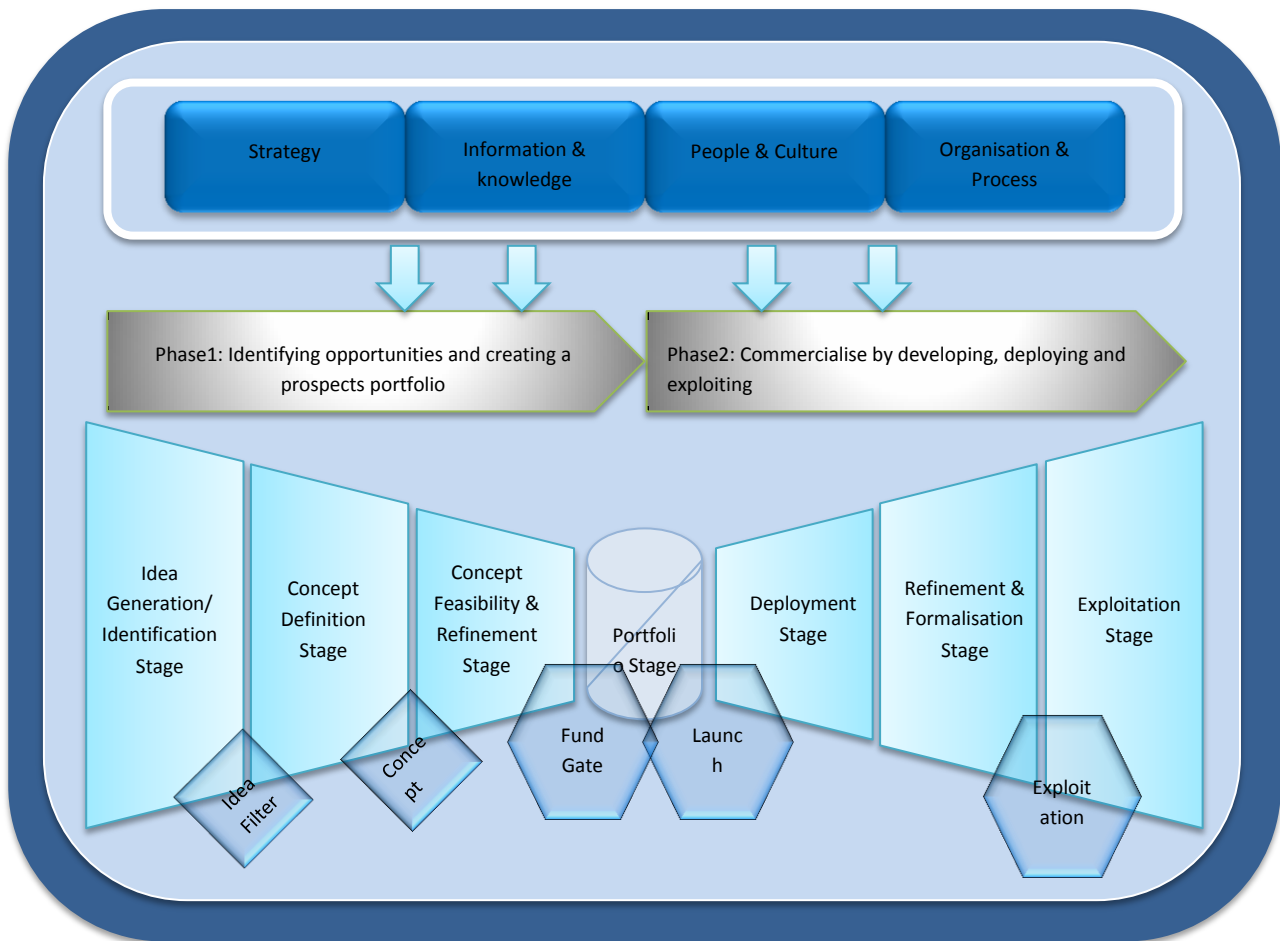
Table 2.1 Development of Innovation Modules (adapted from Du Preez and Louw)

## 2.2 Introduction to the Fugle Model

The Fugle Innovation Process Model was collaboratively developed by the Enterprise Engineering group of the Global Competitiveness Centre, which is located at Stellenbosch University.

The concept of open innovation was first termed by Chesbrough (2003). One of the most obvious benefits of open innovation is the much larger base of ideas and technologies from which to draw the drive for internal growth. But beyond that, leading companies also recognise open innovation as a strategic tool to explore new growth opportunities at a lower risk (du Preez & Louw, 2008). The innovation environment has changed through networking and collaboration. Open innovations call for a new logic, which puts openness and collaboration at the centre. Networks or web communities are the open and agile tools to put the open innovation concept into practice.

The Fugle Innovation Model was built to help businesses to identify, evaluate, develop, implement and exploit new products and services more effectively. The Fugle model no longer only focuses on the internal idea of generation and development, but also combines both internal and external paths to market and advance the development of new technologies. The Fugle model is provided in Figure 2.2



Source: (du Preez & Louw, 2008)

Figure 2.2 Structure of the Fugle Model

The Fugle model assists an organisation in evolving an invention into an innovation. Moreover, the Fugle model leads the ideas and opportunities to be commercialised in the business. A complete Fugle model contains two phases:

Phase 1: Identifying opportunities and creating a prospects portfolio; and

Phase 2: Commercialisation through developing, deploying and exploiting.

Under the two phases, Fugle contains 7 stages to complete an innovation process, which include:

- Idea Generation/Identification Stage
- Concept Definition Stage
- Concept Feasibility & Refinement Stage
- Portfolio Stage
- Development Stage
- Refinement & Formalisation Stage
- Exploitation Stage

Through all the stages of the Fugle innovation process model, a mature innovation product has been generated in a business. The success of the innovation depends on how the inputs, from the previous one to the next, suit the needs and requirements of the organisation or the product.

On the other hand, the Fugle model also maintains that the innovation model aims to help businesses to identify, evaluate, develop, implement and exploit new products and services more effectively and efficiently (du Preez & Louw, 2008).

In terms of the global innovation research, the Fugle process model provides detailed principles with which to compare the differences between how enterprises in different countries generate innovation. It will be used in Chapter 4 to analyse enterprise innovation in South Africa and China.

## **2.3 The Importance of Innovation**

Without any doubt, all businesses want to be more innovative. Every organisation and business feels the impact of globalisation, migration, technological and knowledge revolution, as well as climate change issues. Innovation will bring added value and widen the employment base.

Innovation is vital to growth. A classic case of re-positioning was Häagen-Dazs ice-cream. Until this brand of ice-cream was introduced in the early 1990s, children comprised the main customer base for ice-cream, the product often being regarded as a reward or treat for special occasions. This was reflected in the marketing of ice-cream. However, this

changed with the arrival of Häagen-Dazs. With its high-quality natural ingredients Häagen-Dazs was an example of re-positioning with the product aimed at adults rather than children. This re-positioning was graphically reflected in the early advertising for Häagen-Dazs, which featured a campaign that aimed to “eroticise” the brand through words and images emphasising sensuality and love-making, in order to enhance the appeal of the product to the adult market.

Management expert Peter Drucker said: "An established company, which in an age demanding innovation, is not capable of innovation is doomed to decline and to extinction." (Drucker, 1974) This comment can be seen as the key word of my research on innovation. Innovations appear everywhere in our daily lives. Innovation is involved in any technological improvement, enterprise management and service rendering.

## 2.4 National Innovation Systems (NIS)

In broad terms, a National Innovation System (NIS) can be defined as all economic, political and other social institutions affecting learning, searching and exploring activities to advance a country's innovation profile (i.e. a nation's universities and research bodies, financial system, its monetary policies, and internal organisation of private firms).

The concept of National Innovation Systems basically rests on the premise that understanding the linkages among the actors involved in innovation is a key to improving technological performance (ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT, 1997).

National Innovation was first mentioned in 1983. It was defined as

*“...the set of institutions whose interaction determines the innovation performance of national firms.” (Nelson & Rosenberg, 1993)*

In 1987 Freeman gave the first definition of National Innovation,

*“...the network of institutions in the public and private sectors, whose activities and interactions initiate, import, modify and diffuse new technologies” (Freeman, 1995)*

This quote is now still widely used and never stops adding new content into the definition so that it is suitable for the development of society.

The following elements are usually considered part of a National Innovation System:

- 1) Education and training: Government is in general responsible for education at different levels, which is considered to be the key to the production of sufficient human skills crucial for the production and diffusion of knowledge.
- 2) Science and technology capabilities: The resources invested in R&D, both public and private, differ between countries. It is generally hypothesised that the innovations correlate with the R&D expenses.
- 3) Industrial structure refers to the number of competitors in an industry, their size and their relationships. In general it is hypothesised that strong competition among large firms favours investments in R&D and imitation in particular products and processes.
- 4) Countries differ in degree of specialisation and intensity of R&D expenditures in specific areas. Often government plays an important role in creating a competitive advantage of a NIS in a specific area.
- 5) Interactions within the innovation system seem important for the level of R&D activities and diffusion of knowledge. (Porter M. E., 2001)

Consequently, National Innovation System is not simple. NIS can be broadly defined as all economic, political, financial, educational and other social facilities affecting searching, developing and exploring activities. It includes a nation's research and university bodies as well as fiscal and policy making systems, etc. All these things work together to influence a nation's innovation system.

## **2.5 The Relationship between an NIS and A Country's Economic Success**

National Innovation System (NIS) drives economic growth and ultimately determines the living standards of a country and of its metropolitan areas. Nowadays however, the country faces a growing innovation challenge in global economy.



The study of National Innovation System focuses on flows of knowledge. Analysis is increasingly directed to improving performance in “knowledge based economies” – economies which are directly based on the production, distribution and use of knowledge and information (OECD, 1996).

According to Archibugi, Howells and Michie (1998), technological change provides a privileged viewpoint from which to understand the dynamics of globalisation and the transmission of knowledge has never respected states’ borders (Archibugi, Howells, & Jonathon, 1998). All of the elements of global economy, including governments and companies, have to adapt the rapid technological change in order to survive in the competitive environment. The framework of NIS is a tool that helps a nation in understanding how innovative activities are generated and disseminated.

## **2.6 Chapter Conclusion**

The focus of this chapter was to classify the research target and domain for further study. It also provided background knowledge of innovation and National Innovation System.

The following flow chart shown below, illustrates the information from this chapter.

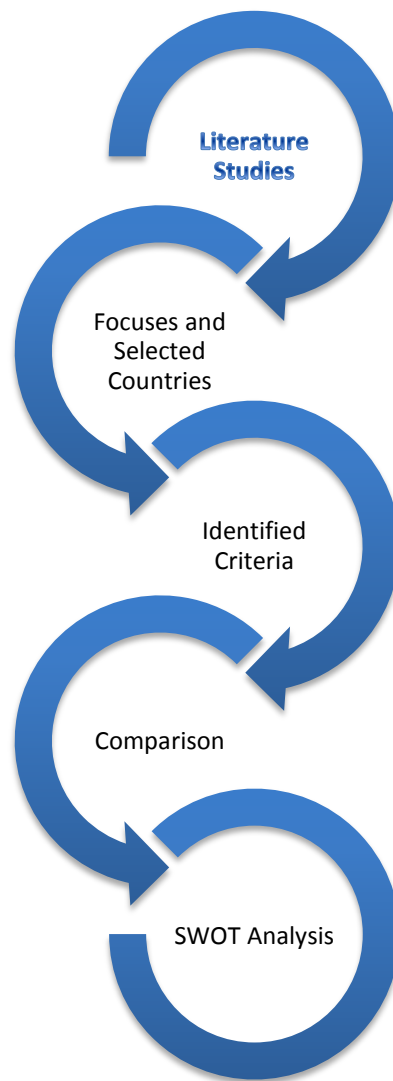


Figure 2.3 Chapter study flows

This chapter introduced the NIS development process and tried to establish the definition of NIS, which can be used for reference in further studies. It also presented why and how the NIS is important to a country and a country's economic development.

The arguments presented to discuss the NIS of South Africa and China need a new approach of doing a comparison analysis, because the understanding of the NIS definition was not absolutely the same in different countries. Therefore, they were not suitable for all economic and cultural backgrounds, resulting in the need for comparison criteria to be investigated.

### **3. Identifying NIS Comparison Criteria**

To compare the National Innovation System between nations, criteria from other NIS reports and literature regarding NIS comparison will be studied to help to determine the focus needs during the process. This chapter gives the process of criteria analysis for future comparison. Simultaneously, criteria will be defined after doing a cluster of literature studies.

### **3.1 Method and Focus**

There is a variety of good examples by other researchers in which a comparison of the innovation systems of countries has been done. One of the first comparative NIS studies was conducted by Michael Porter (Porter M. , 1990). This and his other early comparative studies did not follow a formalised structure and only involved two or three countries. None of the authors of these early comparisons took the respective countries' social, economic and political environment into account.

Many comparative studies on the system-level have been conducted as a preliminary step to generate rankings of NISs. System-level approaches usually try to bridge two aspects: the systemic analysis of innovation processes with emphasis on country-specific elements and comparisons across systems that are abstract from systemic characters.

The studies done by Porter give a general idea of which aspects the study should go into and whether a nation's NIS, in isolation of other national influences, can be used as a tool for governing the competitive environment of another nation. There are, however, many country-specific characteristics that other countries do not have. Because of that, some common systemic elements in National Innovation Systems may be insufficient. So more than one country's innovation system needs to be studied in the comparison, hence the decision to include Finland and the USA in the comparison. The reason will be discussed in the next section.

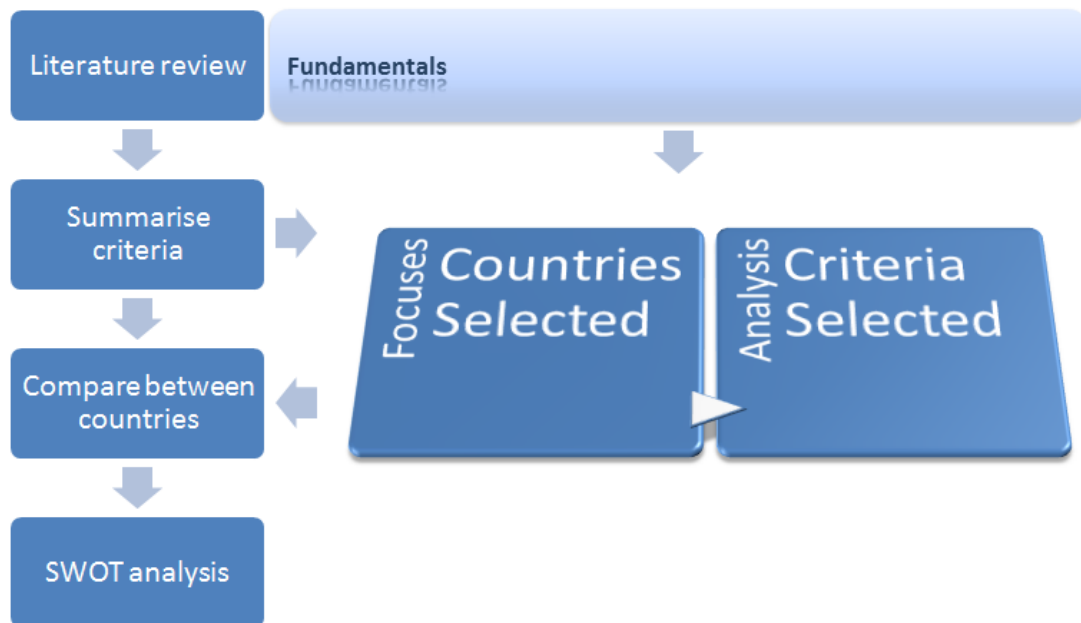


Figure 3.1 Study Methodology

The purpose of finding out the differences via comparison is to try to discover what South Africa and China already have in their innovation system and what they lack. Therefore, the SWOT analysis method will be used to analyse this part for internal and external reasons.

The objective of the thesis will focus on a comparison of National Innovation Systems. The differences and gaps between South Africa, China, Finland and the USA will be analysed in this chapter. Moreover, the thesis will revisit South Africa and China and concentrate on the situation of the Innovation Systems of both countries and try to analyse the reason for differences and gaps from different perspectives.

Some criteria will be established through studying literature from previous comparative study researches of National Innovation Systems. These criteria will be used by analysing the innovative differences between countries.

It is difficult to say which country has the best National Innovation System, even though a country might be the most developed country in the world. As Ramanathan mentioned in his study, National Innovation System (NIS) often means different things to different people.

(Ramanathan, 2010) So, in this study, two countries will be used as a benchmark which will help to analyse the NIS of South Africa and China.

Like other researchers usually do, it is easy to look at ranks and decide which countries have mature innovation systems.

Country	Growth Competitiveness ranking 2003	Growth Competitiveness ranking 2003 among GCR 2002 countries	Growth Competitiveness ranking 2002
Finland	1	1	1
United States	2	2	2
Sweden	3	3	3
Denmark	4	4	4
Taiwan	5	5	6
Singapore	6	6	7
Switzerland	7	7	5
Iceland	8	8	12
Norway	9	9	8
Australia	10	10	10
Japan	11	11	16
Netherland	12	12	13
Germany	13	13	14
New Zealand	14	14	15
United Kingdom	15	15	11

Table 3.1 Growth Competitiveness (OECD, 2004)

Table 3.1 clearly illustrates that Finland and the US are the leading growth competitors in the world. The core reason for this is because they have mature National Innovation Systems and sufficient government monetary investment. Finland posted improvements in its overall macro-economic stability, characterised by an increase in its government surplus,

an increase in its national savings rate, and further reduction of its inflation rate and interest rate spread.

From another perspective, America has the largest economy. It is not difficult to imagine the second economic body in the world and the largest economic country in Africa. As a big country, the U.S. may share many common features with the other two big countries. Finland is not a big country, but it has had the longest time and the most experience in establishing a National Innovation System in history, and it is well-known in textbooks for its innovation system.

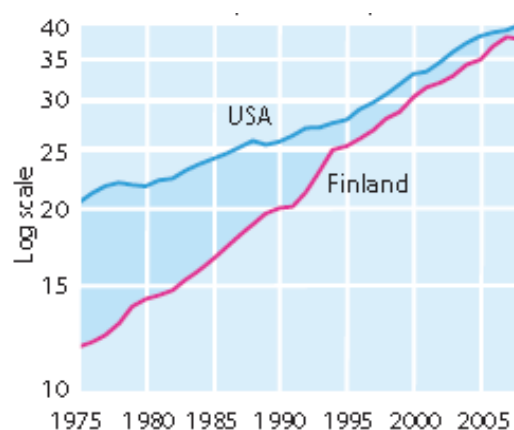


Figure 3.2 Finland and USA Labour Productivity Level

*Resource: (Veugelers, et al., 2009)*

Figure 3.2 demonstrates the Finnish and American labour productivity of non-financial corporations for 2004 in Euros. The chart shows Finland has almost reached the US labour productivity level in recent years. Not only does figure 3.2 show that the USA has better labour productivity, but it also illustrates the rapid rise of Finland's productivity level through innovation transformation, especially after 1990. To analyse the dynamic will provide a role of reference for analysing the NIS of South Africa and China.

To establish criteria for easy comparison of innovation differences, Finland and the United States have mature national systems as the best options for the comparison of the NIS of

China and South Africa. The criteria will be established, based on the analysis of both the advantages and disadvantages of the national systems of Finland and the US.

### **3.2 Identification of Criteria**

In this part, the criteria will be identified and classified according to the literature study of previous research and publications about national innovation systems. By reading those documents, the useful factors that are suitable for research on the South African and Chinese innovation systems will be selected and finally summarised as criteria for this study.

Ramanathan (2010) commented that the interest in NIS came about because experience suggested that in the economically advanced countries of Europe, North America and Asia, government research institutes, universities and the industry worked in close collaboration to promote innovation at company level and thus spur on economic development (Ramanathan, 2010).

In 1997 the OECD introduced the definition and framework of NIS. The article highlighted the joint industry activities, public/private interactions, technology diffusion and personnel mobility as the key factors in the NIS (OECD, 1997).

A UN comparison study done by Trevor Monroe looked at policies, R&D expenditures, Science and High-Tech Clusters in the project which compared NIS of Singapore and Malaysia. (Monroe, 2006).

The work of Fagerberg and Srholec (2008) pointed out the framework of an innovation system also influenced by the quality of “governance”, the character of the “political system”, the degree of “openness” to trade and foreign direct investment (Fagerberg & Srholec, 2008).

Moreover, a report that compared the NIS of Finland, Sweden and Australia, published by Australian Business, involved criteria of sources of capital, skilled labour, networking and policies to evaluate NIS (Roos, Fernström, & Gupta, 2005).



To summarise these NIS research studies, a well-considered framework will be generated and used for this thesis. The factors mentioned in the studies above will be referenced and rearranged as a new framework, and then put out as criteria for following research.

### **3.2.1 Governmental Leadership**

The role that the governments played in stimulating such interaction and collaboration attracted much interest in many countries, which wanted to understand the policies that promoted such interactions and replicate them (Ramanathan, 2010).

The social and political institutions of the NIS function as the institutional selection environment of innovation processes in a country (Groenewegen & van der Steen, 2006). Government policy has tried to target specific groups of entrepreneurs, such as the historically disadvantaged, women, youth or disabled, who are more likely to be poor and unemployed or without opportunities. (OECD, 2007) Allocating resources to these groups involves a trade-off between job creation and redistribution. Regardless of priorities, improved educational access, improved mathematics and science teaching and entrepreneurship education are all crucial.

Governments, as policymakers, have to put high value on an innovation system. Government and legislative agencies should supply the following incentives and protection to NIS:

- Tax incentives
- Financial incentives
- Commercial laws
- Intellectual property protection

A running innovation system cannot operate without coordination from the government, financial facilities or research institutes. The coordination challenge is to ensure an entire government innovation framework across agencies. Moves in some areas would facilitate horizontal policy coordination, but wider action is required. A highly efficient coordination in the innovation system can definitely improve competitiveness.

Government should define the position of the national innovation system in the national strategy of the country and use political and financial tools to strengthen and keep innovation a high consideration in policies.

### 3.2.2 Strategy and Policy

Strategies, in the meantime, need to be conceived in relation to the firm-, sector- and country-specific advantages and disadvantages in the different parts. However, what would be useful to policymakers is a process for identifying these firms and country specific advantages and disadvantages, with policy examples and the contexts within which they have proved successful in the past.

The national innovation strategy should be considered from the following aspects:

- Globalisation
- Sustainable development
- New technology and high technology
- Education

According to an OECD research project, innovation policy has yet to catch up with the globalisation of innovation. To date, policies have largely been ad hoc and aimed at specific problems, such as inward investment. Few countries have worked out how to adapt national policy frameworks to a modern more global innovation system, but small open economies, such as Finland and Ireland, appear to be leading the way (OECD, 2006).

The contributions of the NIS literature had a large impact on policymakers (Groenewegen & van der Steen, 2006). During policy making procedures, governments have to follow the innovation strategy of the country strictly. In order to achieve the optimal level of R&D investment, government policy should aim to bring private incentives in line with the social rate of return.

Innovation policy has to take account of local conditions, economic inequities, demographic challenges and informal economic activity if there are to be positive outcomes. This suggests

that the understanding of innovation policy should have prominence on the development agenda.

### **3.2.3 R&D Expenditures**

R&D expenditure is an important indicator for the innovation activities of a country. It's also the dynamic that pushes technology transfer to the market.

A research study by Rachel Griffith summarised the social rates of return to R&D to be substantially above private rates of return. These rates of return both inform us how important R&D is for growth and provide one of the main justifications for government subsidies to R&D (Griffith, 2000).

R&D expenditure is indexed by most researches on NIS as a critical factor. This research will also measure the R&D expenditure between the target countries.

The R&D expenditure will not only be furthered by seeking money for education and scientific activities but it is also critical to push innovation ideas and achievements in science and commercialising of technology.

### **3.2.4 Human Resources**

Human resources are at least as important as capital inputs and are a crucial building block in S&T development. Countries, like the U.S., use all kinds of incentives in attracting talents from other countries to work in America. No one has a better realisation of how important talents are than the Americans.

Human resources is a complex phenomenon. Its formation is the result of a convergence of various elements which include education, health, secure basic needs provision and a secure base of social capital. Human capital development is the result of a long-term investment process requiring a stable guaranteed environment.

Since World War II, science and technology have become globalised. By allowing people to work in the country, many countries keep high-tech people staying in the country. Most countries have policies particularly for importing special talent.

On the other hand, how to avoid the brain-drain problem is a common issue for most of the developing countries. The following research will analyse how Finland, the USA, South Africa and China manage R&D human resources in both the brain-drain problem and talent import.

### **3.2.5 Higher Education**

Science and technology (S&T) is an essential engine of economic growth. Much of the discussion about human resources and the development of the National Innovation System have centred on the idea of a pipeline running from school education through to higher education at undergraduate and postgraduate levels to the employment of scientists and engineers in R&D activities.

All the education facilities in an innovation system play a role on different levels. Schools, as part of fundamental education, impart basic knowledge and skills and provide suitable students to colleges and universities.

The higher education sector's role in supplying human resources for S&T, and as a key performer of R&D, is of long-running, as well as short-running, importance for the NIS. The universities play an important role as a source of fundamental knowledge and also industrially relevant technology in modern knowledge-based economies.

Universities are important institutions that have long played an important role in generating economic growth and prosperity. However, the means to these ends have evolved considerably over the past two decades as the traditional mechanisms of creating and disseminating knowledge through research and teaching have been joined by a myriad of new initiatives. Many countries around the world are experimenting with new initiatives to promote technology transfer from universities, with varying results.

In recognition of this fact, governments throughout the industrialised world have launched numerous initiatives since the 1970s to link universities more closely to industrial innovation (Mowery & Sampat, *Universities in National Innovation Systems*, 2005).

### **3.2.6 Science and Technology Development**

Science and technology development is one of the most common factors that is used in evaluating the NIS among countries. A country's S&T capability is the concern of all the researches of innovation and innovation systems. Science and technology development is relevant to the potential of the inside capability of innovation and from an angle shows R&D capability as well.

No doubt, Science and Technology development is a benchmark to evaluate the output of the whole R&D system, as well as the input to commercialise the technology. S&T development is the key factor of the entire NIS.

### **3.2.7 Paper Citation and Impact Factor**

Paper citations count how many times the article or journal has been cited or referenced by other research studies. Paper citations of a country in the science and technology area reflect the influence of the country's scientific and technological achievements.

The impact factor, abbreviated IF, is a measure of the frequency with which the average article in a journal has been cited in a particular year or period (Reuters, 2009). It is normally used to compare different journals in certain fields, but in this research it will be used to compare the impact of publications and citations between countries.

### **3.2.8 Intellectual Property Right Protection**

The intellectual property (IP) is defined as "creations of the mind: inventions, literary and artistic works, symbols, names, images and designs used in commerce." (WIPO, 2011) Intellectual property rights give the owners of ideas, inventions, and creative expression the right to exclude others from access to or use of their property for a certain period of time. Protection of intellectual property is an important method for promoting technology innovation and National Innovation Systems.

IPRs are also part of government policies aimed at promoting creativity and the dissemination of technological innovation, as the finite lifespan of IPRs eventually places the innovation in the public domain. Other policy objectives include consumer and producer protection, as consumers could be misled and genuine manufacturers' reputations damaged

by unauthorised use of trademarks and counterfeiting. A fiscal dimension is added in cases of illegally produced or imported counterfeit goods for which no taxes and other duties have been paid to the revenue service. (Teljeur, 2002)

The intellectual property system is one of the cornerstones of modern economic policy at national levels and a catalyst for development. It will increasingly become an important tool for sustainable development in developing countries, especially the least developed countries, in the knowledge-based society of this millennium. Therefore, understanding the legal and economic foundations of the intellectual property system is a prerequisite for comprehending its increasing importance and role in national strategies for enhancing competitiveness and accelerating the socio-economic development (Alikhan, 2000).

### **3.2.9 Technology Transfer**

According to the Fugle innovation module (Chapter 2), innovation and technology need to transform countries from reliance on natural resources to technological innovation. The concept of implementation is emphasised during the commercialisation stage.

Technology transfer or knowledge transfer sometimes, is a key procedure in an entire innovation process. Any single brilliant innovative idea without successful commercialisation means nothing to the entire National Innovation System.

A research study by David C. Mowery and Joanne Oxley (1995) highlights that the economies that have benefited most from inward technology transfer have National Innovation Systems that have strengthened their 'national absorption capacity' (Mowery & Oxley, Inward Technology Transfer and Competitiveness: the role of national innovation systems, 1995). This capacity relies primarily on investments in scientific and technical training, and on economic policies that enforce competition among domestic firms. The particular channels for inward technology transfer, the identity of any 'strategic industries' targeted for public intervention, and the overall level of a nation's trade restrictions are all of secondary importance.

### **3.2.10 Government Research Institute (GRI)**

The Government Research Institute (GRI) plays a key role in many countries' National Innovation Systems. GRIs are not only taking the place of research, but also take massive responsibility for the future plans of the S&T and R&D. GRIs play a leadership role in the whole S&T development and even provide key information to policy level, so that government facilities could plan suitable S&T strategies and policies for the country itself. On the other hand, GRIs also play a very important role in the effectiveness of the government in the NIS. They connect leadership levels to real S&T development levels.

### **3.2.11 Small and Medium Enterprise (SME)**

SMEs play a key role in transition and developing countries. These firms typically account for more than 90% of all firms outside the agricultural sector and constitute a major source of employment, as well as generate significant domestic and export earnings. (OECD, 2004)

The definitions of small and medium-sized enterprises are a bit different in different countries. In Europe, the SME is defined as companies that have fewer than 250 employees and in the USA, the definition changes to 500 employees. In South Africa, the term SMME, for Small, Medium and Micro Enterprises, is used. Elsewhere in Africa, SMME is used, for Micro, Small and Medium Enterprises. The number of employees is a maximum of 100 employees, or 200 for the mining, electricity, manufacturing and construction sectors. In China medium size enterprises can employ up to 2000 people, but assets have to be lower than 40,000,000 Chinese Yuan, equal to about 6,000,000 US dollars.

The difference exists because of the population and situation differences. On the other hand, they all play the same role in each country's innovation system, so the differences will not be discussed in this research.

### **3.2.12 International Cooperation**

International cooperation in innovation is getting more and more important in these times which require knowledge and information. All sectors of the industry are looking for globalisation opportunities. Finland set national innovation institutes in other countries to improve the cooperation of innovation and to look for commercialisation opportunities.

Many analysts and practitioners have argued that, following the ‘globalisation’ of the product market, financial transactions and direct investment, large firms’ R&D activities should also be globalised – not only in their traditional role of supporting local production, but also to create interfaces with specialised skills and innovative opportunities at an international level (Tidd, Bessant, & Pavitt, 2005).

### 3.3 Chapter Conclusion

This chapter focused on defining the methodology and criteria of the comparison. The methods of comparison and the selection of the focus countries were discussed and the criteria were identified by using literature studies. The following table lists the criteria identified and discussed in this chapter.

	Identified Criteria
1	Government Leadership
2	Strategy & Policies
3	R&D Expenditure
4	Human Resources
5	Higher Education
6	S&T Development
7	Paper Citations & Impact Factor
8	IP Right Protection
9	Technology Transfer
10	Government Research Institutes
11	Small and Medium Sized Organisations
12	International Cooperation

Table 3.2 Selected Criteria



The criteria were identified by analysing normal and frequent NIS research criteria that are usually used or referenced in the various country National Innovation Systems. These will be used in Chapter 4 as the basis for the further comparison.

## **4. Comparison between Finland, the USA, South Africa and China**

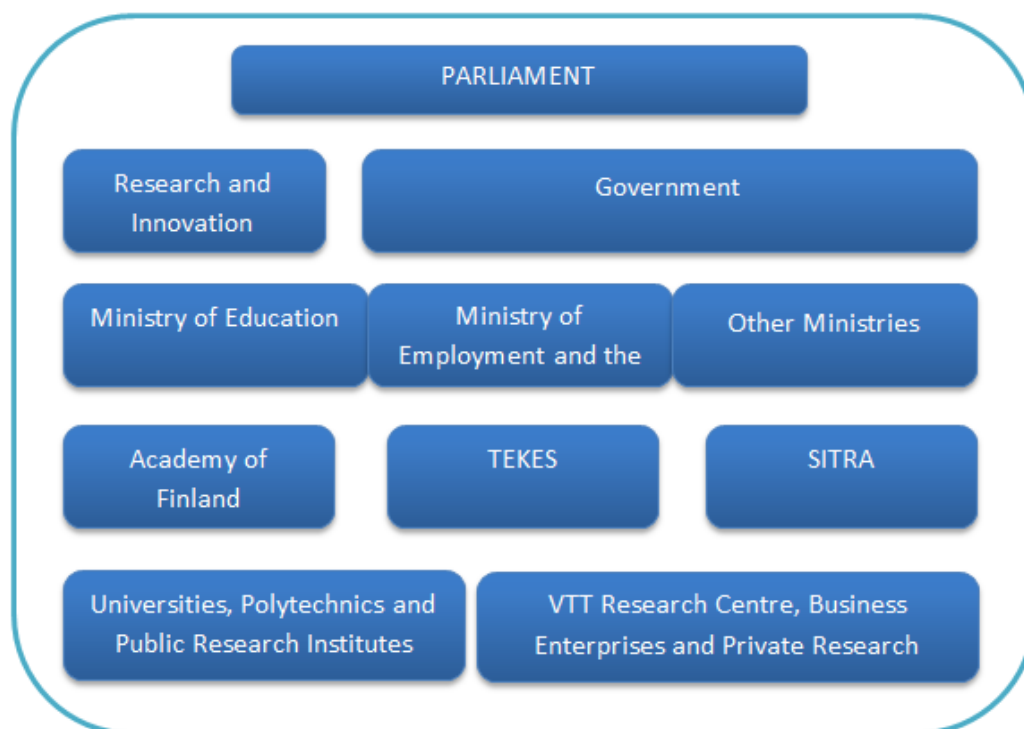
This chapter shows the comparison between Finland, the USA, South Africa and China, using as a basis the criteria identified in Chapter 3 to analyse the situation of the NIS in each country.

## 4.1 Detailed Discussion of Countries' NIS

In this chapter, the criteria which were summarised in Chapter 3 will be used to compare the NIS characteristics of each country. The countries: Finland, the United States (US), South Africa and China were selected for analysis in Chapter 3. Finland and the US will be referenced as benchmarks for the other two countries' NIS, because of their mature NIS development. The result of the comparison will be given at the end of this chapter, and the analysis will be done in Chapter 5.

### 4.1.1 The National Innovation System of Finland

The national innovation system of Finland is an extensive entity comprising of the producers and users of new information and knowledge, as well as know-how and the various ways in which they interact. At the core of the innovation system are education, research and product development, as well as knowledge-intensive business and industry. Varied international cooperation is a feature running through the system.



Source: (Helsinki University, 2009)

Figure 4.1 Structure of Finland's National Innovation System

Key organisations in the Finnish system include (see Figure 4.1):

- The Academy of Finland
- The Finnish Funding Agency for Technology and Innovation (TEKES)
- Public research and development organisations
- Technology transfer agencies
- Capital providers

In Finland the formulation of national science, technology and innovation policies has been assigned to an expert body, the Research and Innovation Council, which is chaired by the Prime Minister. The foremost organisations responsible for science and technology policies are the Ministry of Education and the Ministry of Trade and Industry. The Ministry of Education handles matters relating to education and training, science policy, universities and polytechnics, as well as the Academy of Finland. The Ministry of Trade and Industry is in charge of matters pertaining to industrial and technology policies, the Finnish Funding Agency for Technology and Innovation (called *teknologian ja innovaatioiden kehittämiskeskus* in Finnish, TEKES) and the VTT Technical Research Centre of Finland. Nearly 80 per cent of the government R&D funding is channelled through these two facilities.

According to the introduction of the Finnish innovation system on the website, Finland has moved over from an economy, based on natural resources, towards a knowledge-based economy. The rapid change in the industrial structure has also benefited the primary sector of industry: products and production methods have become more knowledge-intensive in the economy overall. This means that the country is better equipped to face future challenges (Finnish Innovation System).

The other highlights in the Finnish Innovation System are the education investment from the government budget every year and the system of risky investment.

TEKES has built up a remarkable global partnership network, which is more successful than other countries' NIS. Branches of TEKES have located in many innovative countries, as well as fast developing countries to help them improve their innovation chain and also provide excellent frameworks for international R&D cooperation.

<b>China</b>	Beijing and Shanghai
<b>Europe</b>	Brussels
<b>Japan</b>	Tokyo
<b>United States</b>	Silicon Valley and Washington D.C.

Table 4.1 TEKES Branches in the World

TEKES's global operations are part of the FinNode Innovation Centre network that boosts international R&D cooperation and business. TEKES is also the nodal point of many European research activities in Finland.

In 2001, Nokia received a total investment amount from TEKES funding, worth approximately 12 million Euros. For the return of the high investment from TEKES, Nokia has kept growing since the 1990s. Nokia grew extremely fast in the 1990s and became one of the leading high-technology companies in the world. In 2000, the contribution of Nokia on the Finnish GDP reached 2.8% and 20% of Finnish total exports.

Nokia's own operations have reflected on other companies in Finland. The most central channel concerning the innovation system is Nokia's cooperation with other companies. Nokia cooperates both in production and in research and development with numerous companies. In 2000 there were about 300 companies in Nokia's "first tier" partner network. There were from 18,000 to 20,000 employees in these companies, who worked with products delivered to Nokia. One can roughly estimate that, taking into account Nokia's partners, Nokia's share of Finland's employment is slightly below 2.5 per cent (Ali-Yrkkö & Hermans, 2002).

#### ***4.1.1.1 Government Leadership***

TEKES, the Finnish Funding Agency for Technology and Innovation, is the principal organisation for implementing technology policy and is part of the Ministry of Trade and Industry in Finland. It supports companies engaged in risk-bearing product development projects with grants and loans, and finances the projects of research institutes and universities in applied technical research. TEKES launches, co-ordinates and funds technology programmes to be implemented together with companies, research institutes,

and universities. TEKES also has expertise abroad, including coordinating international cooperation in research and technology.

TEKES basically has three major impacting objectives:

#### Capabilities in innovation activities

Strong research and development (R&D) activities, a competence base and networks are particular success factors in broad-based and needs-oriented innovation activities in Finland's key sectors and clusters, for instance, internationality of innovation activities and strong and networked strategic centres. (TEKES, 2010)

#### Productivity and renewal of industries

The growth of the Finnish economy and society is always at the top of the country's concern. Innovation expedites the technology transformation to become the core power of productivity and the renewal of Finnish industries. TEKES also concerns the country's sustainable growth. Young innovation companies and growth companies are supported by TEKES as the current focus.

#### Well-being

Economic growth is integrated with the well-being of people and the environment. Innovations and comprehensive development create a basis for the achievement of societal well-being and environmental objectives. Current focuses are sustainable energy economics and environment, a quality social and health care service system and services, as well as platforms for informing active society. (TEKES, 2010)

Besides this, TEKES has built up a remarkable global partnership network which is more successful than the NIS of other countries. Branches of TEKES have located in many innovative countries and fast developing countries to help them improve their innovation chain and also to provide excellent frameworks for international R&D cooperation.

Another important feature of the innovation system of Finland is the operation and the role of Finland's Research and Innovation Council (OKM). The Science and Technology Policy Council of Finland (STPC) became the Research and Innovation Council in January 2009. The Research and Innovation Council acts as a coordinating body between the Ministries on

research and development issues. The chairman of the council is the Prime Minister of Finland and members include ministers from different ministries and leaders of successful Finnish organisations. The Research and Innovation Council provides a platform for policy discussion among Ministers, industry, funding organisations, unions, universities and government officials.

OKM is responsible for the strategic development and coordination of the Finnish science and technology policy as well as that of the national innovation system as a whole.

#### ***4.1.1.2 Strategy & Policies***

The technology and innovation policy of Finland seeks to contribute to the enhancement and the competitiveness of the Finnish industry, as well as to the well-being of society, with the aim of making Finland capable of providing companies with a top-flight innovation environment internationally, which also attract foreign R&D investments.

During the current term of government, R&D funding will be increased to 4 per cent of Finland's gross national product. This funding will be allocated to centres of strategic excellence in sectors that are pivotal to the development of the national economy, society and citizens' welfare. The regional innovation base, as well as co-operation between business communities and education, as well as research communities, will be strengthened through a Centre of Expertise Programmes that consists of cluster-based networking. (Research fi, 2008)

Finland's Science, Technology and Innovation 2006 Strategy aims to "... ensure sustainable and balanced societal and economic development". The Finnish motivation is that social and economic success is a result of "... a high level education of the population as well as increasingly wide-ranging development and application of knowledge and expertise". Research, development of technology, exploitation of results, and strengthening of social and technological innovation play a crucial role for realizing Finland's objectives of increasing employment and ensuring high productivity and international competitiveness. (National IP Strategy)

The Government's Communication on Finland's National Innovation Strategy to the Parliament, which was taken as the starting point, sets the goal of pioneering in innovation activity in selected sectors of innovation. Communication presents four strategic choices deemed crucial for the future of the Finnish innovation system:

- Innovation activity in a world without frontiers
- Demand and user orientation
- Innovative individuals and communities
- Systemic approach

The Finnish Technology and Science Information Services website highlights that in terms of the competitiveness of companies and the entire innovation system, networking with leading countries and regions in technology is important. Consequently, the network of international innovation centres will be expanded. In addition, a standardisation activity at European and international level is forming a part of the development of the innovation environment.

#### ***4.1.1.3 R&D Expenditures***

The Finnish Funding Agency for Technology and Innovation, TEKES, finances almost 600 public research projects at universities, university-level institutions and research institutes per year. TEKES programmes provide an excellent framework for cooperation for international and Finnish research groups and companies.



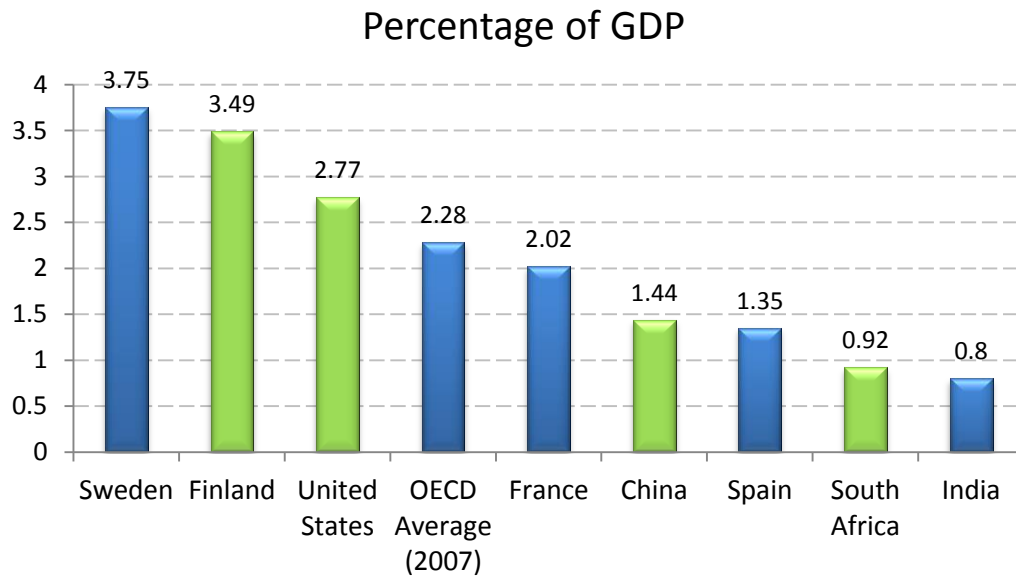


Figure 4.2 R&D Expenditure in percentage of GDP in 2008 (OECD, 2009)

Figure 4.2 demonstrates that the R&D expenditure in each country's GDP differs between Finland, the USA, South Africa and China, and includes a comparison of other nations and organisations.

The Finnish government invested approximately 6.9 billion Euros on research and development (R&D) expenditure in 2008.

Compared to the 2008 R&D expenditure in Finland, government R&D expenditure will increase by 7~10% in 2009. As for 2010, a further 5~10% increase is being considered, along with possible tax incentives for venture capital and business angle investment, including a general R&D tax incentive scheme (Helsinki University, 2009)

#### **4.1.1.4 Human Resources**

Finland is looking to become a destination for high-skilled immigrants but has yet to develop a compelling strategy to attract the top educated talent it is looking for. It is hoped that these immigrants will continue to power the R&D heavy side of the country's high-tech companies. The government is looking to recruit workers primarily from neighbouring countries, but has had to acknowledge the fact that the extreme degree of red tape

involved in applying for residency, as well as the country's high taxes, does not make attractive prospects for would-be immigrants.

#### ***4.1.1.5 Higher Education***

Finland is one of the countries where citizens are educated for the longest period of time. The Education Index, published with the UN's Human Development Index in 2008, based on data from 2006, lists Finland as 0.993 (United Nations, 2008), amongst the highest in the world, tied for first with Denmark, Australia and New Zealand.

Finland has two types of institutes for higher education. "Yliopisto" or called "Universitet" is a university. Another type of higher education institute is "Ammattikorkeakoulu", also called "Yrkeshögskola", which means polytechnics. The selection process is fully transparent, merit-based and objective; there are no application essays, no human factor in selection, no underrepresented minority support, and no weight on extracurricular activities. Moreover, the entrance examinations are rarely long lists of multiple-answer questions, but smaller amounts of longer and more complicated questions that are supposed to test more than memorization and quick mechanical problem solving (Wikipedia, 2011). Therefore, the selection process is very different from that for example in the USA.

In the most voluntary universities and polytechnics, there is no tuition fee charged to students. There are ten multi-disciplinary universities in Finland which include the famous University of Helsinki and seven specialised universities. There are 27 polytechnics in Finland, which also issue bachelor degrees to graduated students.

#### ***4.1.1.6 Science and Technology (S&T) Development***

Finland is a small country in Europe, with a population of only 5 million, and is not rich in natural resources. However, without any doubt, it is a country of high technology, which has a cluster of extremely successful R&D development strategies.

In the 1980s, Finland started their new national strategy with a bundle of new policies that improved S&T development. In 1982, a milestone was reached with the establishment of TEKES. The country started developing a high technology industry.

TEKES, the Finnish Funding Agency for Technology and Innovation, is the principal organisation for implementing the technology policy and is part of the Ministry of Trade and Industry in Finland. It supports companies engaged in risk-bearing product development projects with grants and loans, and finances the projects of research institutes and universities in applied technical research. TEKES launches, co-ordinates and funds technology programmes to be implemented together with companies, research institutes, and universities. TEKES also has expertise abroad, including coordinating international cooperation in research and technology:

- between small and large businesses
- in industry and academia
- in public and private sector and non-governmental organisations
- globally - nationally - regionally

Customers include companies, universities, research institutions, government organisations, local and regional authorities and other organisations operating in Finland.

As a small country, Finland doesn't really have the capability of spreading all kinds of technology research. The route Finland chose was to focus on what Finland is good at, this included well-known technology such as electronics, communications and information technology. As the leader of Finnish enterprises, Nokia was developing extremely fast at a 50% growth rate in the 1980s. Nokia's activity is the stimulus which helps thousands of high technology companies to be involved in high technology industry and to be counted in hundreds of companies which became direct suppliers of Nokia.

Finland maintained a speedy development in the 90s. During 1991 to 1996, Finland's high technology contributed an average 32% growth per year in the field of industry, and contributed 7% of the yearly GDP growth. The weight of the high technology industry raised the country's GDP from 4% to 11.5%. The growth was concentrated in electronic communication equipment, office automation equipment and scientific instrument industries.

Nowadays, the Finnish information index is just lower than the US, being in second place, and the ratio of industrial robot usage ranks 5<sup>th</sup> in the world.

#### ***4.1.1.7 Paper Citation and Impact Factor***

Finland, as a small country, has 14 journals listed on Journal Citation Report (JCR). However, Finland contributed 70,351 scientific papers in 2004, ranked No. 4 in the world (Thomson Reuters, 2009).

		Papers	Citations	Citations Per Paper
ALL FIELDS	Finland Totals	70,351	681,866	9.69
	Rank Among 148 Countries	24	19	17

Table 4.2 Paper Citations of Finland

Universities are involved in 69 per cent of all Finnish publications; the corresponding figure for government research institutes is 17 per cent. Business companies account for six per cent of all publications. (Lehvo & Nuutinen, 2008)

#### ***4.1.1.8 Intellectual Property Right Protection***

Finland recognises Intellectual Property protection as a key driver of service innovation. The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) became internationally effective as from the beginning of 1995.

The protection of intellectual property rights in Finland is provided for not only multilaterally in the TRIPS Agreement and through agreements administered by the World Intellectual Property Organisation, but also through bilateral agreements concluded by trading partners.

#### ***4.1.1.9 Technology Transfer***

VTT Technical Research Centre of Finland is a globally networked multi-technological contract research organization. VTT is originally an abbreviation of Finnish words "Valtion Teknillinen Tutkimuskeskus" which means in English "Finnish Technical Research Centre". VTT produces research services that enhance the international competitiveness of

companies, society and other customers at key stages of their innovation process, and thereby creates the prerequisites for growth, employment and well-being.

VTT Technical Research Centre was established in 1942. VTT is a part of the Finnish innovation system under the domain of the Ministry of Employment and the Economy. VTT is a non-profit-making research organisation (VTT, 2010). The research centre employs about 3,000 people of which more than 60% have a university degree. The main office is in Espoo (Finland) close to the country's capital, Helsinki. VTT's annual turnover is about 200 million Euros. VTT has 12 units (of which 8 are research units/institutes) plus one for studies and one for internal services.



Figure 4.3 VTT's role in Finnish innovation environment

The VTT creates business from technology for the benefit of its customers, partners and other stakeholders. However, VTT is not a profit organisation. VTT works through producing research and innovation services to help companies or society enhance international competitiveness and create the pre-requisites for society's sustainable development, employment and well-being.

The most important contribution in the Finnish innovation system is that the VTT supports opportunities and innovative ideas and research projects are successfully commercialised and thus transfer the investment to become a return to the companies or society.

#### 4.1.1.10 Government Research Institute (GRI)

The government research institutes in the Finnish innovation system take the most responsibility in pushing the S&T development. The government of Finland invests immense amounts of money to the government owned research institutes every year.

There are also 18 state-owned research institutes and several science parks, business incubators and technology centres.

	Budgetary funding million €	External funding million €	Total million €
Finnish Institute of International Affairs	3.1	0.2	3.4
National Research Institute of Legal Policy	1.2	0.6	1.8
Government Institute for Economic Research	4.2	1.0	5.2
Research Institute for the Languages of Finland	5.2	0.5	5.7
Agrifood Research Finland	34.6	15.7	50.3
Finnish Food Safety Authority	1.5	1.2	2.7
Finnish Game and Fisheries Research Institute	9.0	3.3	12.3
Finnish Forest Research Institute	43.2	5.5	48.7
Finnish Geodetic Institute	3.6	1.9	5.5
Finnish Meteorological Institute	16.3	7.3	23.5
Geological Survey of Finland	11.0	2.3	13.3
VTT Technical Research Centre of Finland	85.7	168.3	254.0
Centre for Metrology and Accreditation	2.5	0.5	3.0
National Consumer Research Centre	2.3	0.9	3.2
Radiation and Nuclear Safety Authority	6.2	0.8	7.0
National Institute for Health and Welfare	34.2	29.0	63.2
Finnish Institute of Occupational Health	20.4	9.9	30.3
Finnish Environment Institute	11.3	7.1	18.5
<b>Total</b>	<b>295.7</b>	<b>255.9</b>	<b>551.6</b>

Source: Statistics Finland, Science and Technology

Figure 4.4 Budget funds for R&D and total R&D funds for some government research institutes in 2006

The government research institutes are the core dynamic for Finland's S&T development. The R&D investments from government, except for encouraging enterprises to innovate, are mostly spent on the government research institutes in Finland.

#### ***4.1.1.11 Small and Medium Organisations***

The Finnish Funding Agency for Technology and Innovation (TEKES) provides well-established programmes aimed to encourage SME participation in co-operative research, development and innovation projects.

Despite Finland's scoring high on innovation performance and having engineered one of the most remarkable economic turn-around in recent times (and contemporaneously creating one of the most outstanding global businesses in Nokia), its citizens readily downplay their entrepreneurial capabilities. (Helsinki University, 2009)

#### ***4.1.1.12 International Cooperation***

TEKES can also finance R&D projects undertaken by foreign-owned companies registered in Finland. International companies with R&D activities in Finland do not need to have a Finnish partner to be eligible for funding. The financed project should, however, contribute to the Finnish economy.

With a view to promoting international R&D cooperation, TEKES funds collaborative research, as well as development projects, and facilitates researcher mobility.

After 1995, the year in which Finland joined the European Union, Finland promoted cooperation with other European countries with the Eureka Plan, OECD, COST, ESA and a few more to attract the latest technology and improve Finnish Science and Technology. Finland also uses these channels to help enterprises, research institutions and universities to find new collaboration opportunities. The strategy of high technology development ensured the fast economic growth of Finland.

### **4.1.2 The National Innovation System of the USA**

The transformation of the US economy over the past twenty years has made it clear that innovations based on scientific and technological advances have become a major

contributor to the US well-being. The innovative activity in the US has changed and grown more sophisticated.

The U.S. has a larger and more complicated National Innovation System than Finland has.

The basic functions of this system include:

- Funding for basic research and development;
- Protecting intellectual property, copyrights, and trade-marks, as well as the legal systems of judges and courts that help defend these rights;
- Aiding efforts to set technical standards;
- Agricultural and manufacturing extension services, particularly those helping small business;
- Procurement decisions by agencies;
- General programmes lending more tailored assistance through programmes like the Small Business Innovation Research programmes or the Advanced Technology Programme;
- Protecting the integrity of the overall financial infrastructure;
- Fiscal policies such as taxation and the granting of tax credits;
- Improving the educational system;
- Developing transportation and information infrastructures that facilitate commerce;
- Assisting trade through export financing, protection against unfair trading practices by other countries, identification of trading opportunities and efforts to open markets. (Popper & Wagner, 2001)

The R&D expenditures of the United States account for over 2.5% of the GDP. Apart from the positive effect of the enterprise, the government also has a high proportion of the overall R&D expenditure.

The open American immigration policy has encouraged many top talents to settle in America. The administration of universities, the competitive pressure of enterprise, the political support of government for its need of military products and the financial support of a multi-level capital market all promote the creation and circulation of knowledge.



Another important feature of the American innovation system is its protection of competition through the anti-monopoly law. This law has a positive effect on the innovation of the enterprise.

As people know, America is ahead with knowledge innovation. Large-scale military procurement and a global market for new products have an effective demand for the creation of new products, which encouraged the research investment of enterprises and created many new industries. For those years, the enterprises, which act as the major part of innovation, count for about two-thirds of the total social research investment and undertake about 3/4 of research expenditure.

#### ***4.1.2.1 Government Leadership***

The American Congress plays an important role as a legislative body in the US innovation system. All the government research expenditure must be discussed in both the Senate and the House of Representatives. On the contrary, the Senate and the House of Representatives set their own committees relevant to science and technology separately to be in charge of the innovation policies of researching and legislating.

The United States Senate Committee on Commerce, Science and Transportation is a standing committee in the Senate, consisting of seven subcommittees. There are subcommittees for Competitiveness, Innovation and Export Promotion. In 2005, the Committee on Commerce, Science and Transportation passed the National Innovation Act of 2005. This act is based on a report called Innovation America that was researched by the Council on Competitiveness. In 2006, the committee passed America's Innovation and Competitiveness Act of 2006. This edition referenced a report from the National Academies of Science (NAS): Rising above the Gathering Storm. The content includes increasing R&D expenditure, training specialised personnel and improving innovative infrastructures.

The House of Representatives also promotes the legislation of innovation. In November 2005, the leader of minorities, Nancy Pelosi, published the Innovation Agenda: "A Commitment to Competitiveness to Keep America No.1".

The Office of Science and Technology Policy (OSTP) was established in 1976. The US congress authorized the OSTP to lead inter-agency efforts to develop and implement sound science and technology policies and budgets, and to work with the private sector, state and local governments, science and higher education communities, as well as other nations toward this end.

The mission of the Office of Science and Technology Policy is threefold. Firstly, to provide the President and his senior staff with accurate, relevant, and timely scientific and technical advice on all matters of consequence; secondly, to ensure that the policies of the Executive Branch are informed by sound science; and thirdly, to ensure that the scientific and technical work of the Executive Branch is properly coordinated, so as to provide the greatest benefit to society.

The internal collaboration among government ministries is one of the strengths of the innovation system in the US. This can also be a challenge, particularly at the level of the federal government. Public research funding at the national level is typically implemented through federal agencies, rather than through a single centralised source. Assistance services are typically implemented at state and local levels. The capability of raising programmes depends on the ability of state and local participants to develop new partnerships and networks. Recent studies have raised the need for improved system-wide governance of the innovation system to ensure more effective innovation policies and efficient use of resources.

On the other hand, all states, also as policymakers, have the right to make policies according to their own current demand and situation. This actually distributes the power to the people who can make policies with accuracy.

#### ***4.1.2.2 Strategy & Policies***

As a facility involved with policy and strategy making, the U.S. Office of Science and Technology Policy has made strategic goals for the American National Innovation System.

Strategic Goals and Objectives:

- To ensure that Federal investments in science and technology are making the greatest possible contribution to economic prosperity, public health, environmental quality, and national security
- To energise and nurture the processes by which government programmes in science and technology are resourced, evaluated, and coordinated
- To sustain the core professional and scientific relationships with government officials, academics, and industry representatives that are required to understand the depth and breadth of the Nation's scientific and technical enterprise, evaluate scientific advances, and identify potential policy proposals
- To generate a core workforce of world-class expertise capable of providing policy-relevant advice, analysis, and judgment for the President and his senior staff regarding the scientific and technical aspects of the major policies, plans, and programmes of the Federal government (The Government of the United States).

In the late 1980s, technology extension, standardisation, and university industry research were fostered by the 1988 Omnibus Trade and Competitiveness Act. This legislation also resulted in a reorganisation and new role in technology transfer and innovation for the US Department of Commerce. Legislation in the early 1990s extended and expanded these programmes. Most recently, the mid-2000s saw renewed activity in innovation policy through the America COMPETES Act.

The America COMPETES Act, which stands for the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education and Science Act, was signed by President Bush and became law on 9 August 2007. It is to encourage American and foreign investors investing in innovation industries to improve competitiveness of the US.

The US innovation policy at national level is influenced by the philosophy that commercial innovation is primarily the purview of the private sector, aided by universities and government laboratories, and not directed by the federal government itself. Under this perspective, the primary role of the national government is to facilitate the interactions of these organisations. While the US state governments often take a more explicit role in the

development of the innovation policy, this is not generally the case at federal level. Moreover, innovation is typically at best a second-tier agenda item behind issues such as defence and homeland security, foreign policy, budget deficits, taxing, healthcare and social security (Shapira & Youtie, 2010).

#### *4.1.2.3 R&D Expenditures*

The US innovation system is embedded in an economy that (in the latest annual GDP figures available before the impact of the 2009 credit crunch) reached \$14.3 trillion in output in 2008. US research and development (R&D) investment leads that of other countries in sheer magnitude, \$343 billion in R&D expenditures in 2006, or about one-third of the entire world's R&D. In that year, the US spent 2.6% of its GDP on R&D (National Science Board, 2008). In 2008, the percentage increased to 2.77%.

The National Science Foundation (NSF) is primarily focused on sponsoring peer reviewed basic research, but several of its programmes (such as the Engineering Research Centres or the Industry-University Centres) incorporate industry orientations. Additionally, the NSF is a respected source of statistical information relevant for innovation policy-making and sponsors research projects and initiatives on the analysis and measurement of innovation. (Shapira, P. 2010)

Other federal agencies with large R&D budgets, such as the National Institute of Health or the Department of Defence, also have interests in issues related to commercialisation, dual-use and innovation, related to their missions. Also important in innovation governance is the Small Business Administration, which coordinates one of the largest federal funding initiatives in supporting innovation, the Small Business Innovation Research (SBIR) programme, as well as its companion programme: the Small Business Technology Transfer Programme (STTR). SBIR/STTR is based on the allocation of a portion of the R&D budgets of 11 agencies with R&D budgets of \$100 million. Almost \$2 billion in SBIR/STTR funding was awarded to small and medium-sized businesses with fewer than 500 employees in 2005. (National Academies, 2007)

#### **4.1.2.4 Human Resources**

America has the best human resources worldwide and also the strongest human resources managing system, although America has been suffering employment challenges for the last couple of years. But the US still seems to be the most attractive destination for young students and personnel.

The USA has an excellent overseas performance talent strategy. There were 40% international students that went to America in 2005. In the year 2006~2007, America accepted over 583000 students who studied in the US. 84,000 students were from India as the largest origin country, and then there were China and South Korea.

According to the UN report, there are 33.5 million US residents, comprising of 11.7% foreign born individuals (Rothe, Pumariega, & Sabagh, 2011). Every year, there have been about 1.6 million people moving to the United States, and 40% skilled migrants in the world have chosen the same destination.

To summarise, the team of professionals in the US are either from the United States or are foreign-born consisting of overseas students, immigration and temporary work visa holders. 70% of those people will stay in America after they have finished their education. Highly developed educational environment and highly open and tolerant social environment supply a great capacity and opportunities to personnel which are the core reason the US is attractive.

#### **4.1.2.5 Higher Education**

Education is seen as the key input to an increasingly knowledge-based economy and society in the US. It is also the critical connection between the national innovation system and the larger society.

The research university plays an important role as a source of fundamental knowledge and, occasionally, industrially relevant technology in modern knowledge-based economies. In recognition of this fact, the US governments throughout the industrialized world have launched numerous initiatives since the 1970s to link universities more closely to industrial innovation.

The first universities appeared in Bologna and Paris during the middle ages, and were autonomous, self-governing institutions recognised by both church and local governmental authorities. This situation persisted through much of the period prior to the 18<sup>th</sup> century. But the rise of the modern state was associated with the assertion by governments of greater control over public university systems in much of Continental Europe, notably France and Germany, as well as Japan. However, such centralised control was lacking in Britain, and especially in the U.S. as well as in higher education systems throughout the 19<sup>th</sup> and 20<sup>th</sup> centuries. Throughout the 20<sup>th</sup> century, U.S. universities retained great autonomy in their administrative policies. Rosenberg (1999) and Ben-David (1968) argue that this lack of central control forced American universities to be more "entrepreneurial" and their research and curricula to be more responsive to changing socio-economic demands than their European counterparts. Data allowing for systematic cross-national comparisons of the structure of the higher educational systems of major industrial economies are surprisingly scarce.

Government investment in universities and national laboratories, which engaged in infrastructure development and enterprise investment in basic research, ensured the United States to have a healthy innovative growth in the past 10 years.

The role of educational infrastructure is important in the US innovation system, particularly at tertiary level. Universities in the US are not subject to central chartering by the federal government. Rather, public universities are organised by states (often through large multi-campus state university systems), while private universities are typically established as non-profit organisations. In 2002, there were 2,500 accredited post-secondary educational institutions in the US. However, only 126 of these are considered major research universities according to the Carnegie Classification of Academic Institutions (National Science Board, 2008). Universities perform 16 % of the US R&D but 55% of all basic research.

#### ***4.1.2.6 Science and Technology (S&T) Development***

Without any doubt the United States is one of the most developed countries in science and technology (S&T). Without America's inventions, our modern life would lack a host of things. Cars would have no airbags, people would not have credit cards and cashiers would not

have barcodes with which to scan items, babies would not have disposable nappies, children would not have video games, etc. Since the advent of the 21<sup>st</sup> century, the U.S. has been leading the S&T trend in most fields. The Self-balancing personal transporter was invented in 2001 by Dean Kamen, fermionic condensate was invented by Deborah S. Jin in 2003, the nano-wire battery was invented in 2007 by a Chinese-American, Dr Yi Cui in Stanford, and composite aircraft was developed for the Boeing 787 Dreamliner by the Boeing Company in 2009, etc.

Since the middle of the last century, the U.S. has dominated the science and technology world. A statistic according to the rank of competitiveness of world science and research institutes in 2009, by the UK Royal Society, shows that over 78% of the top competitive research institutes are from the U.S. In the field of Clinical Medicine, America takes 28<sup>th</sup> position out of 30, as well as in the field of Economics and Business.

The science and technology giant, America, has reached the peak of S&T development. Although the U.S. still contributed 316,317 academic papers by 2008, the increment was slight since 1996 when the US published 292,513 papers. The percentage also decreased from 26.3% in the period 1999~2003 to 21.2% during 2004~2008.

#### 4.1.2.7 Paper Citation and Impact Factor

The United States has the most universities and research centres, as well as the most paper citations in the world. The table below shows the citation statistics of the US.

		Papers	Citations	Citations Per Paper
ALL FIELDS (146 countries)	U.S. Totals	2,739,417	35,494,704	12.96
	Rank Among ALL Countries	1	1	6

Table 4.3 Paper Citations of the US

With the highly developed S&T standard, America has 2697 journals listed in the JCR and is ranked No. 1 in the world.

#### ***4.1.2.8 Intellectual Property Right Protection***

The United States provides a wide range of protection for intellectual property through the federal registration of trade marks and service marks; through federal patent protection and copyright protection; and, under state laws, through protection of trade secrets and -marks. Federal protection extends only throughout the United States, its territories and possessions. U.S. IPR laws confer little or no protection in other countries.

The U.S. government protects intellectual property as a national economic foundation. Intellectual property has become one of the major issues of our global society. Globalisation is one of the most important issues of the day, and intellectual property is one of the most important aspects of globalisation, especially as the world moves towards knowledge based economy. How we regulate and manage the production of knowledge and the right of access to knowledge is at the centre of how well this new economy, the knowledge based economy, works and how it identifies its beneficiaries.

Intellectual property is administered through filings to the US Patent and Trademark Office (USPTO). In 2006, the USPTO received 440,000 patent filings and awarded more than 196,000 patents, nearly half of which were granted to foreign-owned firms. In that year, more than 354,000 trade mark applications were filed with USTPO.

#### ***4.1.2.9 Technology Transfer***

In the United States, no government funding is provided to local universities for technology transfer. However, the income recorded from commercialising government-funded-research results has been strictly ruled by law which stipulates that it can only be utilised for three purposes:

1. to fund the administration of the technology transfer function
2. to provide a share of income to the inventor as an incentive to participate in technology transfer
3. to support education and further R&D at the institution

Universities are free to determine how to allocate commercialisation income as they see fit. Most institutions have set aside a portion of income streams to fund the technology transfer



office (TTO): allocations for TTO operations usually range from 10% to 25%. Typically, after allocating a portion of the commercialisation income to support the TTO, the university directly subsidises the TTO from internal sources during the first years of its operation. Then, as income is realised from licence agreements, the subsidy required from universities for TTO operations is reduced over time. Eventually, the institution expects that the income stream generated by the TTO will eventually eliminate the need for a direct university subsidy. As mentioned above, several years are required for a TTO to become entirely self-supporting from the allocated income.

Finally, it should be mentioned that other public research organisations in the United States are funded directly by setting aside the annual appropriation provided to departments by the executive branch of government, such as the U.S. departments of defence, energy, and commerce (Young, 2006).

#### ***4.1.2.10 Government Research Institute (GRI)***

Most American research institutes are commercially operated and that shows the freedom of the American S&T environment.

The most famous leading research institute in the US government is possibly NASA and national economic research associates, but not one of them is a purely American government research institute.

In the United States, policies ensure that all kinds of research facilities receive adequate investment and new technology research is supported by the government, so that the U.S. does not only have many governmental technology and sciences research institutes but also has many others like RAND, Brookings, Council on Competitiveness etc., which are semi-official institutes or private organisations that contribute a great effort to the US innovation system.

#### ***4.1.2.11 Small and Medium Organisations***

America has more than 25 million SMEs in the United States, accounting for 99% of the total number of companies. Those firms supply about half of America's jobs.

The U.S. government provides great support to the SMEs development. Prior to the 1950s, the federal U.S. Small Business Administration (SBA) was created to help small businesses by providing financial and business assistance services.

Since the 1990s, 70 per cent of the U.S. economic growth has come from the export trade, of which 97% of exports come from SMEs. In 2000, in order to accelerate the export growth of SMEs, the U.S. Small Business Administration launched a rapid export credit scheme that was to get export credits within 36 hours. The plan provides for rapid export financing of a maximum of \$ 150,000, of which 10 million dollars in loans available to the SBA guarantee 80 per cent of the credit; 10-15 million in loans are available to 75% of the credit guarantee.

The American government attaches great importance to SME development in the US. The Federal Reserve surveys show that banks provide about 57% of debt finance to SMEs (USA Small Business Administration (SBA), 2003a, 2003b)

#### ***4.1.2.12 International Cooperation***

The United States cooperates widely with most of the developed and fast developing countries. The cooperation covers all aspects, except highly confidential research.

In the S&T development sphere, America is always open to the world. For instance, the American Association for the Advancement of Science (AAAS), also known as “Triple A-S”, is the largest international non-profit organisation. The AAAS was founded in 1848 and serves some 262 affiliated societies and academies of science, serving 10 million individuals. The AAAS provides intergovernmental agreements to scientists who will be eager to work with scientists in other countries and who share these ideals, but they will be hesitant to enter cooperative programmes in which scientific freedom is stultified. Intergovernmental agreements for scientific cooperation will result in little substance unless the scientists of both sides can confidently exercise the freedom that experience has shown is essential in finding the truth.

The government of the United States also stated that S&T cooperation helps to ensure that U.S. scientific standards and practices play a substantial role in the establishment of international benchmarks. It has significant indirect benefits as well, contributing to

solutions which encourage sustainable economic growth by: promoting good will, strengthening political relationships, helping to foster democracy and civil society, and advancing the frontiers of knowledge for the benefit of all (Government of the United States, 2011).

### **4.1.3 The National Innovation System of South Africa**

Since 1994 South Africa has made good progress in improving the governance of their innovation system. The organisational structure of public governance has been transformed by the creation of a government department with responsibility for science and technology (now the Department of Science and Technology), and it appears to be well integrated in cross-departmental interaction at ministerial as well as senior civil servant levels.

A number of new mechanisms for public funding of R&D have been created. Among these, the Technology and Human Resources for Industry Programme (THRIP) has been very effective in integrating the development of research-capable human resources with industry-university cooperation in R&D. The programme has been internationally recognised as particularly successful when compared with similar schemes in other countries. (Department of Science and Technology of South Africa, 2007)

#### **4.1.3.1 Government Leadership**

The National Advisory Council on Innovation (NACI) was created by legislation to advise the Minister of Science and Technology of South Africa, and through the Minister, the Cabinet. The responsibility of NACI is to advise the minister of the role and contribution of science, mathematics, innovation and technology, including indigenous technologies in promoting and achieving national objectives.

The NACI was established in 2000. The council was appointed to advise the Minister and government on a wide range of matters pertaining to innovation policies and systems for South Africa. In 2002, the NACI initiated a review by an international panel to assess the success or otherwise of the implementation of the White Paper on Science and Technology. In general, the review report was positive about the range and nature of policies, strategies and programmes initiated by the department up to that time. (The Evolution of the South

African Science, Technology and Innovation System, 2009) However, one of the major reservations concerned with the difficulty in implementation of policies, was attributed to a lack of human resources, which meant that there were not enough professional staff members for proper implementation.

Other important facilities in South Africa are listed below:

### ***Council for Scientific and Industrial Research (CSIR)***

The CSIR is one of the largest science and technology, R&D and implementation organisations in Africa. The organisation undertakes and applies directed research and innovation in S&T to improve the quality of life of South Africans.

### ***Mintek***

Mintek, South Africa's national mineral-research organisation, is one of the world's leading technological organisations specialising in mineral processing, extractive metallurgy and related areas. Collaborating with industry and other R&D institutions, Mintek provides service test work, process development, consulting and innovative products to clients worldwide. Mintek is an autonomous statutory organisation and reports to the Minister of Minerals and Energy. About 30% of the annual budget of R350 million is funded by the State Science Vote, with the balance provided by contract R&D, sales of services and products, technology licencing agreements and joint-venture operating companies.

### ***Human Sciences Research Council (HSRC)***

The HSRC conducts research that generates critical and independent knowledge, relative to all aspects of human and social development. Alleviating poverty, developing and implementing policy are central to its research activities. The HSRC's research also extends beyond South Africa through projects and collaboration in other African countries.

### ***Medical Research Council (MRC)***

The MRC conducts research through six national programmes, and collaborates with most of the world's top health-research agencies to improve the nation's health status and quality of life. The MRC disseminates research information through the National Health

Knowledge Network. The council has established the African Biotechnology Information Centre in co-operation with various universities. The MRC's National HIV & AIDS Lead Programme coordinates the South African AIDS Vaccine Initiative.

### ***Agricultural Research Council (ARC)***

The ARC is committed to promoting agriculture, and related sectors, through research and technology development and transfer.

In August 2008, the Department of Trade and Industry launched South Africa's first aerospace supplier village. Situated in Centurion, Pretoria, the village is expected to unlock the potential of South Africa's aerospace industry. The primary objective of the Centurion Aerospace Village (CAV) is the development, construction and operation of an aerospace supplier park. In addition, the CAV addresses the upliftment of small and medium enterprises and black empowerment companies within the industry and repositions the aviation sector to ensure participation in the global aviation market. Government's vision is that, by 2014, the South African aerospace industry should be sustainable, growing, empowered and internationally recognised. The village will house a number of local industry companies, including Denel and Aerosud Holdings, as well as smaller companies in what will be a cluster-focused development.

### ***Council of Geoscience (CGS)***

The CGS supplies the country with geoscience data to establish a safe and cost-effective physical infrastructure.

### ***South African Bureau of Standards (SABS)***

The SABS produces, maintains and disseminates standards. It promotes standardisation in business and government and administers compulsory standards on behalf of the State. It also certifies international quality standards. (South Africa Online)

The South African Government has three key interests in the South African Innovation System which can be thought of as being:

- to ensure that South Africa has in place a set of institutions, organisations and policies which give effect to the various functions of a national system of innovation
  - to ensure that there is a constructive set of interactions among those institutions, organisations and policies, and
  - to ensure that there is in place an agreed upon set of goals and objectives which are consonant with an articulated vision of the future which is being sought.
- (Department of Science and Technolgy of South Africa, 1996)

### ***The Technology Innovation Agency (TIA)***

The Technology Innovation Agency (TIA) was incorporated in terms of the TIA Act of South Africa in 2008 (Republic of South Africa, 2008).

The TIA is tasked with exploiting the existing body of knowledge at universities and public research institutions and bridging it effectively towards the development of science and technology based industries.

#### ***4.1.3.2 Strategy & Policies***

In the mid 1990s, South Africa re-established its science and technology (S&T) policies in the form of the National Innovation System. Strategies for indigenous knowledge, nanotechnology, astronomy and intellectual property, derived from publicly funded research, have been developed in South Africa.

The new government faced challenges in basic development. Having focused on the future for so long during the struggle, they now had to deal with the urgent service delivery needs of the present. Not surprisingly, the new funding scenarios required re-direction of the remaining technology competencies towards missions emphasising quality of life and economic competitiveness. However, the emphasis was on reprioritisation rather than the funding of new missions. Within this policy space, the White Paper on Science and Technology approved by the Cabinet in 1996, established a policy framework for science and technology in South Africa based on the concept of a National System of Innovation (Department of Science and Techonolgy of South Africa, 2007).

The analyses of the innovation policy in South Africa reveal that there are many challenges for the National Innovation System which will require specific corrective measures. After an extensive process of public consultation and stakeholder review, the Department of Environmental Affairs and Tourism (DEAT) has released a draft National Strategy for Sustainable Development (NSSD) that currently serves as a discussion document within a public consultative process. The 2006 Strategy looks forward for 20 to 30 years, but will be updated regularly to ensure that the 20 to 30 year Vision and Action Plan remains hopeful, relevant and realistic.

As the Science and Technology White Paper described, South Africa currently lacks a national policy to facilitate the country's optimal integration into the global information society and outlining clear responsibilities, goals and targets. This is a serious defect in their overall innovation drive and must be remedied as soon as possible. Information society planning must now take place at the highest levels within South Africa to develop a national vision, policy and strategy for meeting their specific needs. (Department of Science and Technology of South Africa, 1996)

The policy of The Black Economic Empowerment (BEE) has played an important role since. BEE is one of the most important policies of the government of South Africa involved in the nation's economy.

South Africa's policy of BEE is not simply a moral initiative to redress the wrongs of the past. It is a pragmatic growth strategy that aims to realise the country's full economic potential. In the decades before South Africa achieved democracy in 1994, the apartheid government systematically excluded African, Indian and coloured people from meaningful participation in the country's economy.

All in all, there are at least 24 laws as well as policy and regulatory provisions dealing with empowerment. They cover more than ten sectors, nine gambling boards, ten government tender boards, tender boards of state enterprises, a marine council, broadcast and telecommunication authorities, small business promotion bodies, a privatisation fund and labour relations institutions (Business Map, 2006). Some of these provisions include: the

Employment Equity Act (1998), which requires employers to implement affirmative action in favour of Previously-Disadvantaged Individuals (PDIs) to ensure equitable representation in the workplace; the Preferential Procurement Policy Framework Act of 2000, which provides a framework to encourage procurement from empowered entities; and the Skills Development Act (1998), which provides an institutional framework for improving the skills of the South African workforce (Bezuidenhout et al., 2005).

Criticism of black empowerment has also come from outside the investor community. Most South Africans believe something must be done to increase opportunities for all but they still view BEE as problematic. Some regard it as a form of discrimination, even "reverse racism".

#### *4.1.3.3 R&D Expenditures*

According to the statistics of the department of science and technology, South Africa spent just over R18.6 billion on research and development (R&D) in 2008, which represents an increase of R2.1 billion of the Gross Expenditure on R&D (GERD) compared to R16.5 billion in 2007. The R&D expenditure in 2008 takes a share of 0.94% of the GDP in the same year. (OECD, 2009)

The Innovation Fund is one of the main agencies responsible for the implementation of the R&D Strategy in South Africa. It aims to promote competitiveness by investing in technologically innovative R&D projects, the effect of which will be new knowledge and widespread national benefits in the form of novel products, processes or services.

Initially, the Innovation Fund assumed the role of a funding agency, supporting research projects carried out by consortia (typically made up of some combination of universities, science councils and/or firms). While it reserved the right to share in any future profits generated out of funded projects, it left project management largely in the hands of the project consortia. The Innovation Fund is, however, currently in the process of refashioning itself into an entity that more accurately resembles a venture capital investor, applying typical venture capital investment criteria, as well as requiring additional requirements to be met, in order to achieve various government socio-economic policy objectives, including



broad-based Black Economic Empowerment (BEE). This has resulted in a substantially more intensive and protracted process of evaluation and due diligence of proposals (often taking a year or longer), and a much more hands-on approach to project design and management (Wolson, 2007). The government's target is to transfer 25% of formal economic wealth to black people over the next 10 years.

#### *4.1.3.4 Human Resources*

The South African government views human resources as their national asset. The concepts of human resources development (HRD) refers to the process whereby people, either individually or collectively, acquire the knowledge and skills necessary for specific occupational tasks as well as for the other social, cultural, intellectual or political roles associated with a vibrant democratic society (Department of Science and Technology of South Africa, 1996). However, the reality is that South Africa is facing a serious brain-drain problem which is not only caused by political reasons.

South Africa continues to strengthen enterprise-level training supported by the levy grant and the Sector Education and Training Authorities (SETA) system, with its emphasis on basic, artisanal and technical skills and also takes steps to stimulate investments by business enterprises, especially medium-sized and larger firms, to develop their higher-level human resources for innovation. (Department of Science and Technology of South Africa, 2007)

In 2001, the S&T personnel situation was 7 researchers per 10,000 members of the South African labour force, compared to 27 in Korea and 48 in Australia.

In South Africa, with a total of 31,352 full-time equivalent (FTE) R&D personnel, there is a marginal growth of an already small quantity. This category comprises of researchers, technicians and other support staff. About 62% of these personnel comprise the 19 320 researchers or academically qualified people who perform, manage and guide the process of undertaking research that leads to new knowledge and novel research findings.

In South Africa, recent studies have shown attrition rates for researchers of approximately 11% per annum from government laboratories and 15% per annum from universities. Of

those who leave employment, some 5% of the government laboratory scientists and about 22% of the academics emigrate.

#### ***4.1.3.5 Higher Education***

Highly educated people play a critical role in the NIS. The Department of Education of South Africa is responsible for the administration and coordination of education in South Africa across all sectors, but each of the nine provinces has its own education department.

Higher Education South Africa (HESA) is the umbrella body responsible for public higher education institutions, and the Council on Higher Education (CHE) advises the Minister of Education on strategic issues in higher education. The Higher Education Quality Committee (HEQC) promotes quality assurance, audits the quality assurance mechanisms, and accredits the programmes of higher education institutions.

There are 21 public universities, including 5 universities of technology. Many of South Africa's universities are world-class academic institutions at the cutting edge of research in various spheres.

The South African higher education was restructured in 2005. A new type of institution, designed to cater for the merger of some universities with former "technikons" became comprehensive universities.

#### ***4.1.3.6 Science and Technology (S&T) Development***

The Technology and Human Resources for the Industry Programme (THRIP) is supported by the national Innovation Fund and Ministry of Science and Technology. It aims to boost South African industry by supporting research and technology development.

South Africa has the Hartebeesthoek Radio Astronomy Observatory, the Hermanus Astronomy Centre and the iThemba Laboratory for Accelerator Based Science of which South Africans are proud.

South Africa gained 7205 patents in 2007 and 7740 patents were granted in 2008, which shows an increase of 7.4%.

South African S&T development has had remarkable achievements. The technologies of medicine, chemistry, material, laser, mining and astronomy etc. have made an enormous contribution. In 1999, the first satellite of Africa, Sunsat, which was designed by Stellenbosch University, was launched successfully. The heart transplant, CAT scans, speed guns, Cybertracking satellite navigation, Tellurometer revolutionised mapmaking and oil from coal technology from SASOL are all South African technology archives.

#### **4.1.3.7 Paper Citation and Impact Factor**

According to the Journal Citation Reports (JCR), the journal has a 2009 impact factor of 0.506 for South Africa. The journals statistic of JCR (Journal Citation Report) shows that South Africa has 33 scientific journals on the list at present.

According to the ISI essential Science Indicators, South Africa had 188,685 citations in 2005 and ranked 33<sup>rd</sup> out of 152 top performing countries. The tables below contain rankings and citations in South Africa.

	Citations	Citations per Paper
South Africa	Rank (out of 152 countries)	33
	All fields <sup>1</sup>	188,685
		71
		4.91

Table 4.4 South Africa's Paper Citations

#### **4.1.3.8 Intellectual Property Right Protection**

South Africa is – on balance – a technology importer. Total cross-border receipts for copyrights, royalties, etc. (captured inter alia under 'other services' in the services account of the balance of payments), amount to approximately R400 million per year and payments from South Africa to the rest of the world for these services are estimated at R1.5 billion per year, leading to a net deficit on the technology balance of payments of R 1.1 billion per annum. (Teljeur, 2002)

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<sup>1</sup> All Fields: stand for total numbers of citations in all fields.

South Africa makes provision for intellectual property protection according to four categories:

- Patents
- Designs
- Trade marks
- Copyright.

These protect the works of writers, artists, or photographers. Although registration is not required, knowing how the protection works, and what limitations there are, is extremely important to prevent infringements of copyright. It falls under the regulation of the Copyright Act 98 of 1978.

#### *4.1.3.9 Technology Transfer*

A weakness of innovation trends in South Africa is the low technology transfer of the research base. Patenting activity in South Africa is very low.

South Africa has made government support for research and innovation a key part of the national economic-development strategy. In August 2002, South Africa's government approved a new national R&D strategy, and discussions continue for implementing the new strategy, including national funding for technology transfer. Funding for commercialisation activities and patents is critical, but a major capacity-building and development effort is under way. This effort will build upon capabilities that exist in a few universities and public research councils. (Young, T. 2007)

South Africa is seeking to build strong links between its emerging technology transfer system and S&T system. The Southern African Research & Innovation Management Association (SARIMA) was formed in 2002 to assume the lead role in national efforts to build capability in research and innovation. SARIMA was established to build a new culture of innovation inside the research community and to ensure that all benefits of research are understood and exploited in South Africa.

As part of its national strategy, the South African government established its innovation fund to promote technology innovation, which has increased networking and cross-sector collaboration. The fund has invested R650 million in more than 100 projects. Many of these have produced patents and in some cases spinout companies. Most recently, the government established the Innovation Fund Commercialisation Office (IFCO), a centralised office to provide one-stop support for protecting and commercialising intellectual property rights for all of the nation's public research organisations. IFCO complements existing technology transfer offices in South African public research organisations. (Young, T. 2007)

#### **4.1.3.10 Government Research Institutes (GRI)**

There are numerous higher education institutions and independent research institutes in South Africa involved in undertaking research across many disciplines.

South Africa has 8 national research agencies which belong to different ministries.

<b>ARC</b>	Agricultural Research Council
<b>CSIR</b>	Council for Scientific and Industrial Research
<b>CGS</b>	Council for Geoscience
<b>MRC</b>	Medical Research Council
<b>Mintek</b>	South Africa's National Mineral Research Organisation
<b>SABS</b>	South African Bureau of Standards
<b>HSRC</b>	Human Science Research Council
<b>NRF</b>	National Research Foundation

Table 4.5 South Africa National Research Institutes

Except the NRF, 7 other agencies are not only doing their specific research, but also help enterprises to solve technological problems and give technological support.

The National Research Foundation (NRF) manages South Africa's national research facilities. It promotes and supports basic and applied research. The NRF oversees the following national research facilities:

- South African Astronomical Observatory
- Hartebeesthoek Radio Astronomy Observatory
- Hermanus Magnetic Observatory
- South African Institute for Aquatic Biodiversity
- South African Environmental Observation Network
- National Zoological Gardens
- iThemba Laboratory for Accelerator-based Sciences (iThemba Labs) (South Africa Online)

#### **4.1.3.11 Small and Medium Organisations**

The term of Small, Medium and Micro Enterprises, short for SMME, in South Africa is the main dynamic of South Africa's economy. It also takes massive responsibilities on S&T development.

The National Small Business Act of 1996 defines a 'small business' as follows:

*... a separate and distinct business entity, including co-operative enterprises and non-governmental organisations, managed by one owner or more which, including its branches or subsidiaries, if any, is predominantly carried on in any sector or sub-sector of the economy mentioned in column I of the Schedule.*

Small businesses can be classified as micro, very small, small or medium enterprises, following a complex set of thresholds. (Department of Trade and Industry, 2008)

The National Small Business Act (National Small Business Act, 1996) categorised business as five types: survivalist enterprises, micro enterprises, very small enterprises, small enterprises and medium enterprises. Due to the comparison between the countries, the SMME, defined by The National Small Business Act, will be classified as SME as for the other three countries. Although the definition is slightly different, SMME has the same function in South Africa's National Innovation System as with the other SMEs.

The importance of SMMEs within the South African economy is that they share most of the general characteristics of the sector elsewhere, but also face some challenges which are particular to the South African context.

According to the Registrar of Companies' 1990-2000 statistics, Small and Medium enterprises represented 97.5% of the number of registered businesses in SA, employed 55% of the country's labour and generated approximately 68% of total remuneration in 2002. (Financial Mail, Johannesburg, 2004)

#### ***4.1.3.12 International Cooperation***

South Africa has wide international cooperation with many countries on R&D. Europe is One of South Africa's most strategic partnerships in international science and technology. South Africa and Europe have built a strong science and technology connection through the European-South African Science and Technology Advancement Programme (ESASTAP). ESASTAP aims to promote improved cooperation between South African and European research groups and highlights South African S&T excellence internationally to encourage S&T partnerships.

In terms of collaboration, publications can be classified into collaborated and non-collaborated papers. Collaboration happens at the domestic level when authors are from within the country or at the international level when at least one author joins from overseas. Domestic collaboration is further bifurcated into internal-institutional (authors belonging to the same department or institution within South Africa) and external-institutional (authors from different institutions in South Africa). Out of the total of 2,036 papers produced during the period of analysis, 1,492 (73%) were collaborated papers. The proportion of collaborated papers was 56% in 1975 which had increased to 81% by 2005. The papers produced in internal-institutional collaboration declined from 75% in 1975 to 47% in 2005. On the other hand, external-institutional collaboration grew from 10% in 1975 to 19% in 2005 (Sooryamoorthy R. , 2011).

South Africa is also involved in many African cooperation programmes that aim to build capacity as part of a research-for-development focus. South-South cooperation with other

emerging economies has also become prominent. The India, Brazil, South Africa partnership, for example, includes active collaboration in biotechnology, space programmes and nanotechnology.

#### **4.1.4 The National Innovation System of China**

China has an old civilization and historically, has made important contributions to global science and technology. In the older history of China, however, science and technology as it evolved in Western Europe was not regarded as important or as carrying social status. While the heritage from Confucius gave high prestige to the intellectuals, it was to intellectuals engaged in humanistic science and in political and administrative affairs. Scientific and technological knowledge was seen as based upon practical experience, rather than as a modern type of scholarship. Whereas Research and Development (R&D) establishments started to be organised in the 1920s to 1930s, China could only begin the process of institutionalization of modern science and technology nationwide in the 1950s.

The second feature was the separation of industrial R&D centres from productive enterprise users. The centrally planned regime had introduced particular mechanisms to link up R&D activity with production: All the R&D institutes, except those belonging to the Chinese Academy of Sciences were organised under the jurisdiction of sector specific ministries or bureaus, independently outside enterprises. The ministries or bureaus took the responsibility for planned production tasks as well. They were hence in command of both R&D and production (Gu & Lundvall, 2008).

The institutional setting was reflected in innovation characteristics. For example, the machinery industry of China was apt at “general purpose” machinery, and weak in technology fulfilling particular machining tasks since these could only be developed through interactive learning and close producer-user communication (Gu, 2006).

##### **4.1.4.1 Government Leadership**

Government innovation incentives, R&D tax deductions, the Chinese premier, Wen Jiabao's commitment to make China an innovation-centred economy and unique patent types (such as utility models) contributed to China's acceleration to the spot of top innovator.



As the Chinese economic landscape changes, major shifts are occurring in patent filings: agri-centred innovation related to food production is growing much more slowly than high-technology innovation. There was a 4,861 per cent increase in domestic Chinese patent applications in digital computers in the decade from 1998 to 2008, versus a much more modest increase of 552 per cent in natural products and polymers for that same period.

China has two major national academic institutes. The Chinese Academy of Sciences (CAS) was founded in Beijing on 1 November 1949. It is a leading academic institution with comprehensive research and development concentrating on natural science, technological science and high-tech innovation in China. The Chinese Academy of Engineering (CAE) was established in 1994. The CAE is a national and independent organisation composed of elected members who have the highest honour in the communities of engineering and technological sciences. They provide consultancy services for decision-making of the nation's key issues in engineering and technological sciences and promote the development of the undertaking of engineering and technological sciences in China and devote themselves to the benefit and welfare of society.

The government effectiveness of the Chinese innovation system partly indicates governmental research institutes. The power of expediting S&T in China is mostly from government research institutes, national universities and academies that belong to the government. The purpose for that is to concentrate on R&D resources and to avoid wasting research for the country. This phenomenon matches the Chinese political logic that everything belongs to the nation.

According to the statistics from the Chinese Ministry of Science and Technology, the usage of R&D expenditure for basic research projects was less than 4.8% of the total expenditure and 12.5% in applied research in 2009, although government effectiveness is, without doubt, high. However, the lowest basic research investment percentage in the world shows that the fact of Chinese R&D expenditure usage is not free and scientific. It shows that government power is very involved in the NIS.

The Chinese government, however, is giving enormous support to S&T development. Government S&T appropriation increased from 56.7 billion Yuan in 2000 to 258.2 billion Yuan in 2008, approximately 38.6 billion US dollars.

#### ***4.1.4.2 Strategy & Policies***

The Strategy for Invigorating the Country through Science, Technology and Education was made and published in 1995.

Technological innovation of enterprises to protect the laws and regulations is not perfect. Since reform and opening its doors, China has formulated and implemented the "Scientific and Technological Progress Law" and the "Scientific and Technological Achievements Law", as well as other laws and regulations, which were formally implemented by the State in 2003. The "SME Promotion Law," compared with developed countries but China still has no uniform primary and secondary Enterprise Basic Law, which makes it difficult for SMEs to develop a special status and individual characteristics of the corresponding legal norms. It is impossible for SMEs to provide equal competition, technological innovation and the legal environment and effective property rights incentives. Due to the lack of legal expertise to promote innovation in small and medium enterprises and SMEs, a number of areas related to technological innovation cannot follow, and find it difficult to clear all of the main technological innovation within the SME's rights and obligations and cannot provide sufficient incentives for technical innovation for SMEs.

Policymakers in Beijing, looking to strengthen China's economy, are no longer satisfied with the country's position as the world's manufacturer. Their solution is to break China's dependence on foreign technology, moving from a model of "Made in China" to one of "Innovated in China."

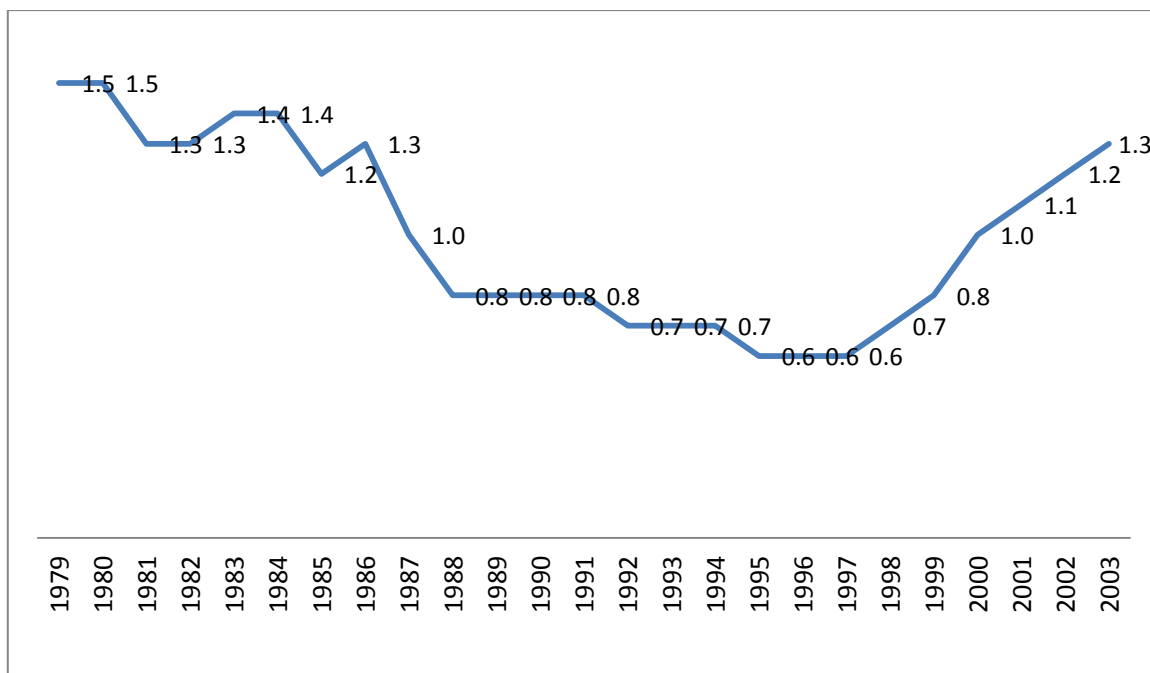
#### ***4.1.4.3 R&D Expenditures***

The expenditure on research and development (R&D) in China reached 461.6 Chinese Yuan which was equivalent to US\$69.3 billion in 2008. According to the data from OECD, the R&D expenditure in 2008 shares 1.44% of the GDP for that year. The government contributed 108.9 billion Yuan, which was 23.6% of the total R&D expenditure; and enterprises

contributed 71.7% of the total of 331.2 billion Yuan, whereas higher educational institutes shared 8.8%. (OECD, 2009)

The crucial event for the R&D system reform came in 1985, and slightly lagged behind the agricultural and industrial reforms, which were started in 1978 and 1984 respectively. In 1985 a decision made by the Central Committee of the Communist Party of China initiated the reforms in Science and Technology System Management. The central theme for the reform was to rearrange the relationship between knowledge producers and users on the one hand, and their relationships with the government, on the other hand, in a context where demand, supply and coordination factors were changing and reform of the S&T system was seen as indispensable. (Gu & Lundvall, China's Innovation System and the Move Toward Harmonious Growth and Indigenous Innovation, 2008)

The detail of R&D expenditure percentage growth based on the Chinese GDP is shown below.



Source: (China's Innovation System and the Move Toward Harmonious Growth and Indigenous Innovation)

Figure 4.5 Percentage of R&D Expenditure Based on GDP from 1979 to 2003

The diagram showed the constant R&D expenditure growth since the 90s and acceleration of the growth. The growth rate gave a positive result after 1997, although the percentage is still too low in the GDP.

#### *4.1.4.4 Human Resources*

The large number of R&D personnel is one of the most important strengths for China in its S&T development. Human resources are at least as important as capital inputs and are crucial building blocks in S&T development. The large number of R&D personnel is one of the most important strengths for China in its S&T development.

The total number of personnel in science and technology activities and R&D human resources increased dramatically and the number of R&D human resources increased from 498,000 in 2000 to 700,000 in 2004. The eastern region of China became the “highlight” of science and technology personnel. In 2006, China had the second highest number of researchers in the world, just behind the United States, and ahead of Japan and the Russian Federation.

Currently, the aggregate number of S&T professionals is 42 million, second to none in the world; the total of full-time equivalent (FTE) R&D personnel is 1.9 million, ranking second globally.

To train more better-educated personnel and solve the problem of a lack of higher education resources, the Chinese government encourages students to study overseas. The Ministry of Education of China estimated that 134,000 students went overseas in 2007 and the number was over 150,000 in 2008.

However, there are problems accompanying the trend of studying overseas. According to the latest census data of the OECD, there were 718,000 highly skilled Chinese-born residents in OECD countries: 57% of them stayed in the U.S. and 18% in Canada, which creates a brain-drain problem for China.

In recent years, the higher education sector in China has begun to attract a larger number of foreign students. In 2003, 34,000 foreign students graduated from higher education

institutions in China, which was more than 10 times the number in 1991. In 2005, the number of foreign students who came to China for higher education reached 141,087, which was more than ever before. Among them, 7,218 foreign students were funded by Chinese Government scholarships, while 133,869 were self-supported. More detailed information is needed, such as their country of origin, the subjects of their studies and the impact on the higher education system in China. (Schaaper, 2009)

The purpose for that is not only for academic communication, but the Chinese government also realised that once people have studied in a certain country, they often stay there to start a career. The Chinese government uses this phenomenon to attract more highly-skilled labour to work in China.

#### ***4.1.4.5 Higher Education***

China's current higher education system was largely shaped by the history of the last 50 years since the founding of the People's Republic of China in 1949. During this period, two opposing forces played an important role in the formation of the current system: the centralised Soviet education model and the informal Chinese education model. These two forces worked together to generate the current two overlapping systems: the regular higher education system and the adult higher education system. Both systems were administered by central ministries and provincial or municipal governments. Only in recent years have private higher education institutions begun to emerge.

By the end of 2004, China had 2,236 colleges and universities, with over 20 million students enrolled.

In China, the number of researchers increased by 77% between 1995 and 2004. China now ranks second worldwide with 926 000 researchers, just behind the United States (more than 1.3 million), and Russia ranks fourth. Singapore employs more researchers per thousand of the total employment than the OECD average.

In 2009, China's high-tech human resources amounted to 51 million, topping the world; unfortunately, great scientists like Qian Xuesen are rarely seen. In 2007, the quantity of Chinese scientists who published scientific papers on SCI took the second place in the world.

However, few of those scientific achievements are original and no one has gained the first prize in the field of national natural science. In 2008, the total expenditure in research and development reached 457 billion RMB, 40 times higher than that in 1978. However, core technologies are still controlled by other countries and Chinese external dependence on technology is still higher than 60% .

In the higher education sector, China opened the doors for students to study overseas. According to the statistics of the Ministry of Education of China, in 2005, 119 000 Chinese students were studying abroad, almost 6 times as many as in 1995. Among them, in 2004, 91% were self-financed, and 70% went to Europe, North America, Australia and Japan. In the same period, the number of returnees also increased. It reached 35,000 in 2005 corresponding to 30% of the number of Chinese students going abroad in the same year.

However, not all Chinese students who go abroad are registered with the government. The use of data from receiving countries shows that many more Chinese students were studying abroad than were registered in China, a total of 395 000 students in 2005, which shows an increase from 126 000 students in 1999.

#### ***4.1.4.6 Science and Technology (S&T) Development***

The Science and Technology capability of China has improved enormously in the last decade. In the early 21st century, the gap in high-technology research and development between China and the world's advanced countries has shrunk; 60 per cent of technologies, including atomic energy, space programmes, high-energy physics, biology, computer and information technology, have reached or are close to the world's advanced levels. On 15 October, 2003, the successful launch of the "Shenzhou V" manned spacecraft made China the third country to master manned spaceflight technology. According to the Moon Probe Project started in February 2004, China would launch unmanned probes to the moon before 2010, and gather moon soil samples before 2020.

China granted a total of 93706 invention patents in 2008, which is ranked second in the world. While innovation by domestic entities is driving China's patent boom, China is also expanding its IP protection overseas. From 2007-2008, the growth rate of China's overseas

patent filings in Europe, Japan and the U.S. was 33.5%, 15.9% and 14.1%, respectively. (Ministry of Science and Technology of China)

#### 4.1.4.7 Paper Citation and Impact Factor

Today in the People's Republic of China, there are more than 8,000 academic journals, of which more than 4,600 can be considered scientific. In 2008, China had an impact factor of 0.736, ranked at no. 8 in the world. The impact factor increased to 0.957, still ranking no. 8 out of 44 countries in 2009. (Thomson Reuters, 2009)

According to the ISI essential Science Indicators, among the 145 top-performing countries in all fields, the People's Republic of China ranked no.6 for citations, no. 13 for papers, and No. 117 for citations per paper. The tables below contain rankings and citations in China.

<b>China</b>	<b>Rank</b>	<b>6</b>	<b>117</b>
	All fields	1,718,847	3.86

*Resource: Essential Science Indicators from the July 1, 2007 update covering a 10-year plus 4-month period, 1997-June 30, 2007.)*

Table 4.6 Paper Citations of China

Due to the language limitations, Chinese citations are apparently not referenced by other non-Chinese countries frequently. That is the external cause. Moreover, the internal cause of the fact that China has low citations per paper is that the Chinese S&T development pursues the number of the fact papers published, rather than the quality.

#### 4.1.4.8 Intellectual Property Right Protection

Since The Patent Law was launched in 1985, intellectual property right has developed vibrantly in China. However, the Patent Law weakly protects the right of intellectual property, especially for some foreign high-tech companies.

In China, 79% of computer users use pirate software, ranking 27<sup>th</sup> in the world in 2009, compared with 20% for the US and 35% for South Africa which is an excessive figure. China had the most Internet users, a total of 240 million, at the end of 2009. It could be said that

the loss for the software industry, not only for the U.S. but also for local Chinese software producers, is immeasurable.

The same phenomenon happens not only in the software sector, but also in car manufacturing, military industry, construction material and other high technology.

New Chinese policies prompted by the report have raised the hackles of foreign governments and technology enterprises. As China is a massive consumer of high-tech products, the government announced in 2009 that in order to be a recognised vendor in the government's procurement catalogue, a company would have to demonstrate that its products included local innovation and were free of foreign intellectual property. Yet since R&D is a global, collaborative process, no individual high-tech product is completely independent of technology from outside of China. In April 2010 Beijing ordered those high-tech companies, seeking to be listed in its procurement catalogue, to turn over the encryption codes of their smart cards, internet routers, and other technology products.

The Senior Director for Greater China at the U.S. Chamber of Commerce, Jeremie Waterman, testified before the International Trade Commission in June that a weak legal environment allows Beijing to "...intervene in the market for IP and help its own companies 're-innovate' competing IPR as a substitute to foreign technologies."

Apparently, the United States is dissatisfied that China freely uses technology without paying for intellectual property, then "re-innovates" and sells it back to America at a lower price.

China has made some concessions, though, in May 2009, Cao Jianlin, the deputy minister of the Ministry of Science and Technology, noted that the 2009 procurement policy was an early draft and that future revisions would address concerns over IPR protection. Beijing has also announced that it intends to join the World Trade Organisation's Agreement on Government Procurement, a treaty that ensures non-discriminatory access to government purchases for foreign companies, "...as soon as possible."



#### **4.1.4.9 Technology Transfer**

Chinese products always give the impression that they are sleazy, but in reality the high- and mid- technology products are getting a bigger and better proportion of the country's trade. High-tech import's share in total imports increased from 16.3% in 1995 to 34% in 2008. Export in high-tech products has increased rapidly, from 20 billion US Dollars in 1995 to around 415.6 billion US Dollars in 2008 and shares 29.1% of total exports.

A research project shows that before 1998, only Tsinghua University and Peking University in Beijing operated technology transfer offices (TTO) in China. Today, most public research organisations in China have a TTO. These were originally supported by the Chinese government, but as China moves from a state-planned economy to one that is more market based, this TTO funding model is changing. Today, most of the TTOs operate as associated private companies, solely owned by the corresponding university and initially supported with university funds. As private companies, these TTOs are very active in business-development services, such as setting up incubators, assisting small- and medium-sized enterprises to prepare business plans, helping develop spin out company requirements, investing in new spin out companies with university-based venture funds (Young, 2006).

#### **4.1.4.10 Government Research Institutes (GRI)**

In China's national innovation system, government research institutes are still playing a key role in supporting basic and strategic research, and research related to the provision of public goods. The research activities of government research institutes in China are highly concentrated in the field of natural sciences and high-tech related disciplines. In 2005, expenditure on natural sciences and engineering accounted for 94.7% of the gross R&D project expenditure of government research institutes.

The size and complexity of the S&T-system made reform crucial for the success of economic growth. By 1980 there were 4,690 research institutes affiliated to administration bodies higher than the "county" level, i.e. to central, provincial, and regional/city governments, with some additional 3000 institutes at county level, the lowest level of the nation's administration hierarchy with an independent budget. 323,000 scientists and engineers

worked in these institutes (Gu & Lundvall). China has more than 500 main government research institutes covering almost all science and technology fields.

The current situation of government research institutes is to a large extent the result of the industrial conversion started in 1999 and the re-classification reform in 2000. The purpose of these reforms was to adjust the role of government research institutes, on the one hand through downsizing the number of institutes and S&T personnel without formal qualification, and on the other hand by strengthening government support to those institutes with research capacity in basic and applied research, and in research fields which have a public goods nature.

#### *4.1.4.11 Small and Medium-sized Enterprises*

The statistical definition of SMEs varies from country to country, and is usually based on the number of employees, capital, or the value of assets and sales volume. According to the Chinese Government, SMEs are roughly characterized as having fewer than 200 employees, with a sales value lower than 300 million Yuan or capital value lower than 400 million Yuan. For the purposes of the present paper, we will adopt this relatively inclusive definition, although the term SME is used more significantly in the context of small and medium-sized firms in the technology sector, producing tradable (technological) goods and services. (Kanamori, Lim, & Yang, 2007)

The economic transition of China has led to an increase in the importance of small and medium-sized enterprises, which currently represent 99% of all Chinese enterprises. Approximately 75% of the total jobs in urban areas are held at SMEs, which absorbed a big part of the labour force formally employed by state-owned enterprises as well as most of the 200 million rural migrants moving into urban areas since the beginning of the reforms. Nonetheless, the importance of SMEs for the Chinese economy and society was only recognised some years ago. Despite their growing significance, SMEs still lack appropriate promotional structures and instruments.

Although SMEs are taking the majority of quantity, big enterprises are still the main power of Chinese economy. According to the statistics from the share market, SMEs hold only

approximately 20% of the total market value and big companies and nation-held companies take the rest. This illustrates that the contribution to the economy from SMEs is still limited; it also means that, relatively, SMEs do not play the main role in the Chinese National Innovation System.

At present, the Chinese government's financial support to SMEs is mainly in the form of special funds for investment and investment in industrial policy. Banks, who grant loans for SMEs, include the China Minsheng Bank, city commercial banks, urban credit cooperatives and other financial institutions.

#### ***4.1.4.12 International Cooperation***

China has cooperated, through programmes in science and technology, with 152 countries and regions, signed inter-governmental sci-tech cooperation agreements with 96 countries and joined more than 1,000 international sci-tech cooperation organisations. Non-governmental international cooperation and exchanges have also been increasing. (Science and technology in the People's Republic of China)

On average, 16.7% of all inventions filed at the European Patent Office (EPO) were owned, or co-owned by a foreign resident in the period 2001-2003, a notable increase from 11.6% in the period 1991-1993. The extent of internationalisation, as reflected in foreign ownership, varies substantially across countries. (Schaaper, 2009) In China, 47% of domestic inventions belong to foreign residents, a much higher share than in the United States, the EU or Japan.

The International Scientific and Technological Cooperation Award of China is a national science and technology award, established by the State Council. It is granted to foreign scientists, engineers and managers, or organisations that have made important contributions to China's bilateral or multilateral scientific and technological cooperation. By the end of 2004, 35 foreign experts had won the award.

The government of China is offering S&T aid to less developed countries, and encourages research institutes and companies to "Go Global".

## 4.2 Comparison Summary between Finland, USA, South Africa and China

	Finland	USA	South Africa	China
Government Leadership	<p>TEKES is the principal organisation for implementing technology policy and is part of the Ministry of Trade and Industry in Finland.</p>	<ul style="list-style-type: none"> <li>The United States Senate Committee on Commerce, Science and Transportation is a standing committee in Senate consisting of seven subcommittees.</li> <li>The Office of Science and Technology Policy (OSTP)</li> </ul>	<ul style="list-style-type: none"> <li>The National Advisory Council on Innovation (NACI)</li> <li>Department of Science and Technology</li> </ul>	<ul style="list-style-type: none"> <li>Ministry of Science and Technology</li> <li>Chinese Academy of Science</li> <li>Chinese Academy of Engineering</li> </ul>
Strategy & Policies	<ul style="list-style-type: none"> <li>Innovation activity in a world without frontiers,</li> <li>demand and user orientation,</li> <li>Innovative individuals and communities, and</li> <li>systemic approach.</li> </ul>	<p>The U.S. Office of Science and Technology Policy have made strategic goals for the American National Innovation System.</p>	<ul style="list-style-type: none"> <li>National Strategy for Sustainable Development (NSSD)</li> <li>BEE influences</li> </ul>	<p>Moving from a model of “made in China” to one of “innovated in China.”</p>
R&D Expenditures	<ul style="list-style-type: none"> <li>R&amp;D expenditure 6.9 billion euro (9 billion dollars)</li> <li>3.49% of GDP in 2008</li> </ul>	<ul style="list-style-type: none"> <li>R&amp;D expenditure 340 billion dollars</li> <li>2.77% of GDP in 2008</li> </ul>	<ul style="list-style-type: none"> <li>R&amp;D expenditure 18.6 billion rand (2.6 billion dollars)</li> <li>0.94% of GDP in 2008</li> </ul>	<ul style="list-style-type: none"> <li>R&amp;D expenditure 461.6 billion RMB (69.3 billion dollars)</li> <li>1.44% of GDP in 2008</li> </ul>

	Finland	USA	South Africa	China
Human Resources	<p>Finland is looking to recruit workers primarily from neighbouring countries, but has had to acknowledge that the extreme degree of red tape involved in applying for residency and the country's high taxes do not make attractive prospects for would-be immigrants.</p>	<ul style="list-style-type: none"> <li>America accepted over 583000 students who studied in the US.</li> <li>11.7% of American population are immigrations until 2003</li> <li>70% of foreign-born people would stay in America.</li> </ul>	<ul style="list-style-type: none"> <li>About 31 352 full time equivalent (FTE) R&amp;D personnel</li> <li>Researchers in R&amp;D Per Million of Population 360.94</li> </ul>	<ul style="list-style-type: none"> <li>49.7 million R&amp;D personnel in 2008</li> <li>1.9 million full time equivalent (FTE) R&amp;D personnel</li> <li>Researchers in R&amp;D Per Million of Population 852.03</li> </ul>
Higher Education	<ul style="list-style-type: none"> <li>10 multidisciplinary universities</li> <li>7 specialised universities</li> <li>27 polytechnics</li> </ul>	<ul style="list-style-type: none"> <li>2,500 accredited post-secondary educational institutions</li> <li>126 of these are considered major research universities</li> </ul>	<ul style="list-style-type: none"> <li>16 academic universities</li> <li>5 universities of technology</li> </ul>	2,236 colleges and universities, with over 20 million students enrolled.
Science & Technology Development	<ul style="list-style-type: none"> <li>In 2008, Finland granted 997 invention patents.</li> </ul>	<ul style="list-style-type: none"> <li>No.1 patents granted country</li> <li>157,772 invention patents granted in 2008</li> </ul>	<ul style="list-style-type: none"> <li>Obtained 7740 patents granted in 2008</li> <li>Obtained 7205 patents granted in 2007</li> </ul>	<ul style="list-style-type: none"> <li>Total 93,706 invention patents granted in 2008</li> </ul>
Paper Citation and Impact	<ul style="list-style-type: none"> <li>Finland has earned an average of 9.69 citations per</li> </ul>	<ul style="list-style-type: none"> <li>USA has earned an average of 12.96 citations per</li> </ul>	<ul style="list-style-type: none"> <li>South African authors have earned an average of 5.2</li> </ul>	<ul style="list-style-type: none"> <li>Citations of Chinese journals covered by Science Citation Index</li> </ul>

	Finland	USA	South Africa	China
Factor	<p>publication.</p> <ul style="list-style-type: none"> <li>Finland has 14 journals in JCR</li> </ul>	<p>publication.</p> <ul style="list-style-type: none"> <li>America has 2697 journals that are listed in JCR top of the world.</li> </ul>	<p>citations per publication in the last 30 years.</p> <ul style="list-style-type: none"> <li>South Africa has 33 journals in JCR</li> </ul>	<p>were 0.326 in 1999. But total amount ranked No.8 of the world in last 10 years.</p> <ul style="list-style-type: none"> <li>China has 137 journals in JCR.</li> </ul>
Intellectual Property Right Protection	<p>Finland recognises Intellectual Property protection as a key driver of service innovation.</p>	<ul style="list-style-type: none"> <li>Intellectual property is administered through filings to the US Patent and Trade mark Office.</li> <li>The USPTO received 440,000 patent filings and awarded more than 196,000 patents in 2006.</li> </ul>	<p>35% computer users use piracy software</p>	<ul style="list-style-type: none"> <li>The Patent Law</li> <li>79% computer users use piracy software</li> </ul>
Technology Transfer	<p>The most important contribution in the Finnish NIS is that the VTT supports opportunities and innovative ideas.</p>	<p>Universities are free to determine how to allocate commercialisation income as they see fit.</p>	<p>The Southern African Research &amp; Innovation Management Association (SARIMA) invested South African Rand 650 million in more than 100 projects</p>	<ul style="list-style-type: none"> <li>Exports of high-tech products 415.6 billion US Dollars in 2008</li> <li>Share 29.1% of total exports</li> </ul>
Government Research Institute (GRI)	<p>There are also 18 State-owned research institutes and several science parks, business incubators and technology centres.</p>	<p>In the United States, policies ensure that all kinds of research facilities receive adequate investment.</p>	<p>7 main national research agencies</p>	<ul style="list-style-type: none"> <li>More than 500 government research institutes.</li> <li>Main power of R&amp;D in China</li> </ul>

	Finland	USA	South Africa	China
Small and Medium-size Organisations	The Finnish TEKES provides well-established programmes aimed to encourage SME participation in co-operative research, development and innovation projects.	The Federal Reserve surveys show that Banks provide about 57% of debt finance to SMEs	<ul style="list-style-type: none"> <li>• SMEs represent 97.5% of the number of registered businesses</li> <li>• Generate approximately 68% of total remuneration by 2002.</li> </ul>	<ul style="list-style-type: none"> <li>• Around 75% of total jobs in urban areas</li> <li>• SMEs hold only approximately 20% of total share market value</li> </ul>
International Cooperation	TEKES can also finance R&D projects undertaken by foreign-owned companies registered in Finland.	The United States have wide cooperation with most of the developed and fast developing countries	<ul style="list-style-type: none"> <li>• ESASTAP is the main collaboration programme.</li> <li>• Wide cooperation with African countries</li> </ul>	China has built collaborative relationship in science and technology with 152 countries and regions.

Table 4.7 NIS Comparison Summary between Finland, USA, South Africa and China

### **4.3 Chapter Conclusion**

The purpose of this chapter was to list the NIS content for Finland, US, South Africa and China based on the criteria which are summarised in Chapter 3. All the information has been attached to each criterion that showed the current situation or development history.

In the comparison table at the end of the chapter, a horizontal comparison was done through the wide literature study to illustrate the differences between four countries.



## **5. SWOT analysis of South Africa and China**

This chapter uses the SWOT method to analyse the NIS of South Africa and China. The purpose of this chapter is to use the information given in Chapter 4 to give the final analysis and conclusion of the NIS in South Africa and China.

A SWOT methodology and advantages and disadvantages of the NIS of South Africa and China will be introduced firstly, and then the identification of opportunities for collaboration between them with the SWOT method will be attempted.

## 5.1 SWOT Analysis Methodology

In this chapter the SWOT analysis method is going to be used to analyse the NISs of South Africa and China. The SWOT analysis method will be introduced firstly, and then an explanation of the reason for choosing the SWOT method for the analysis will be given.

### 5.1.1 SWOT Literature

SWOT analysis is a strategic planning method used to evaluate the Strengths, Weaknesses/Limitations, Opportunities, and Threats, also known as SLOTT, involved in a project or in a business venture. It involves specifying the objective of the business venture or project and identifying the internal and external factors that are favourable and unfavourable to achieve that objective. The technique is credited to Albert Humphrey, who led a convention at Stanford University in the 1960s and 1970s using data from Fortune 500 companies (Wikipedia, 2011).

SWOT analysis, basically, needs three steps. The first step involves the collection of information which has been done in Chapter 4. In the second step the information is refined to make sure that it is trustworthy and usable, and that all the information is arranged according to the SWOT Matrix. A review of the SWOT matrix with a view to create an action plan with which to address each of the four areas is done in the third step.

Table 5.1 illustrates how the SWOT analysis matrix can be presented.

	POSITIVE/ HELPFUL	NEGATIVE/ HARMFUL
INTERNAL Origin	<b>Strengths</b> Things that are good now, maintain them, build on them and use as leverage	<b>Weaknesses</b> Things that are bad now, find a remedy, change or stop them.
EXTERNAL Origin	<b>Opportunities</b> Things that are good for the future, prioritise them, capture them, build on them and optimise	<b>Threats</b> Things that are bad for the future, put into plans to manage them or counter them

Table 5.1 SWOT Introduction

Classified as follows, the first row of the SWOT analysis matrix shows strengths and weaknesses from the internal perspective and the second row shows opportunities and threats from the external perspective, from which an analysis will be done. While the left column presents the positive things in the system, the right column demonstrates negative or harmful factors. It can also be read that opportunities are the future strengths of the objective and that threats are going to be weaknesses of the system.

### **5.1.2 Analysis Method Employed in the Research**

This chapter uses the SWOT analysis method to analyse the advantages and disadvantages, according to the information that has been given in the comparison. The result will cover the main characteristics of the South African and Chinese Innovation Systems and reveal similarities and differences.

To input the information into the SWOT analysis, the comparison conclusion from Chapter 4 will be refined in this chapter.

According to the comparison, all criteria will be analysed, firstly, to point out what they are. Each criterion can be a single result, or it can be defined as two or three analysing results. For example, South African Government Leadership could be the only Strength in SWOT, or it could be Strength and Threat at the same time.

South Africa and China will be analysed together for each criterion in order to determine their similarities or differences and/or opportunities for cooperation. A conclusion will be given at the end of each criterion, followed by a table in which the motivation for the conclusion is explained and which leads to the process of building up to the final conclusion of the SWOT analysis.

The result for each aspect of the criteria will be shown in a table and be graded from very bad, poor, moderate, good and excellent. After this the average for each aspect will be summarised. The conclusion of Strength, Weakness, Opportunity or Threat will be given according to this score.

In order to provide a more immediate comparison to the NIS analysis, the basic analysis results will be presented in star diagrams. According to the analysis above, it will transfer from the levels: very bad, poor, moderate, good and excellent to a score of 1 to 5.

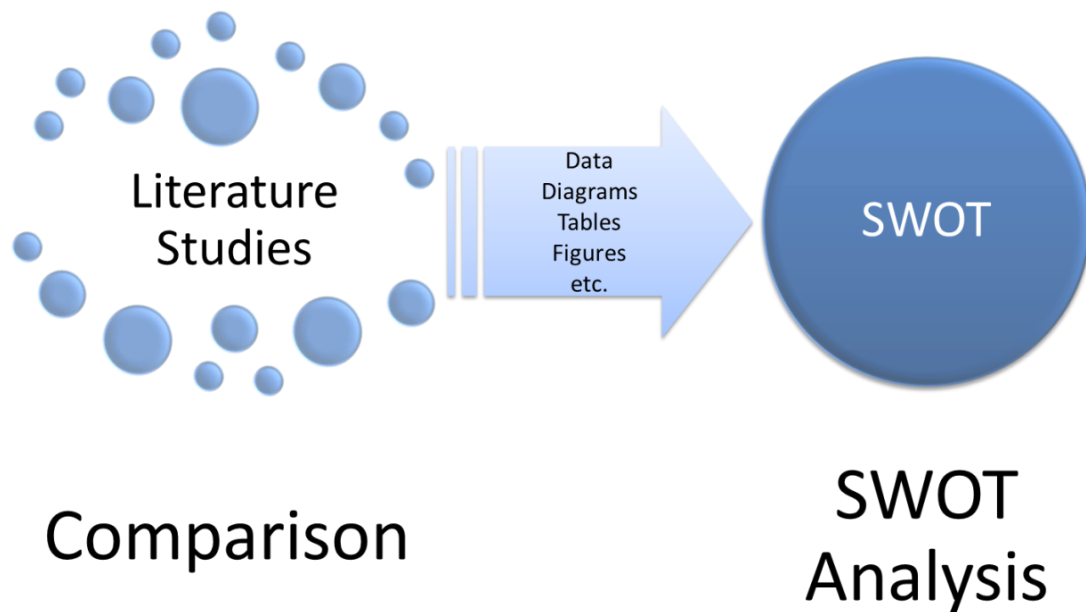


Figure 5.1 SWOT analysis process

Finally, a SWOT analysis result will be illustrated in two separate SWOT analysis tables that will show the final result of the analysis, followed by the conclusion. Possible correlation will be analysed at the end.

## 5.2 Analysis Process

Analysis process is done by using the previous literature study in Chapter 4 input to be changed to a SWOT analysis structure. This part is the real comparison that focuses on the advantages and disadvantages of both South African and Chinese innovation system.

### 5.2.1 Government Leadership

The core of government leadership in South Africa's NIS is the National Advisory Council on Innovation (NACI). This body was established at Cabinet level to provide a holistic overview

of strategies, policies and budgets for the development of the system and to ensure a balance between departmental initiatives that make competitive claims on the systematic resources, especially the human resources. (Department of Science and Technology of South Africa, 2007)

China maintains a strong expectation that by using government innovation incentives, tax deductions and a few more, an innovation-centred economy will be built. China has two major national academic institutes, the Chinese Academy of Science (CAS) and the Chinese Academy of Engineering (CAE), leading the R&D development of the country.

### **Initiate Strategy and Policy**

South Africa was the first country in the world to adopt this framework as its national policy. This policy framework was further developed in South Africa's National Research and Development Strategy that was published in 2002. (Oerlemans & Pretorius, 2006)

As it was mentioned in Chapter 4, the range and nature of policies, strategies and programmes, initiated by the department up to that time, was shown positively in the evaluation report.

One of the major reservations, where South Africa is concerned, is the difficulty in the implementation of policies, which was attributed to a lack of human resources, which means that there was not enough professional staff for effective implementation. Therefore, according to two referenced reports, the weak point of government leadership in South Africa's NIS is the focus on human resources.

The Chinese government continues to play a central role in Chinese science and technology development as well as in promoting high-tech industry innovation. As is PRC government practice, Beijing continues to outline the nation's long-term priorities and plans for S&T development (WALSH, 2005). As mentioned in Chapter 4, the Chinese premier, Wen Jiabao's commitment to make China become an innovation-centred economy, as well as unique patent types (such as utility models) contribute to China's acceleration to the top innovator spot. In Beijing, officials have begun to formulate the goals to be set out in the next or the 12<sup>th</sup> Five-Year Plan, which will guide Chinese S&T efforts over the period 2011-2015. This

plan will no doubt include further lofty objectives to which China's S&T community will aspire. Chinese NIS clearly shows advantages and confidence on this aspect of government leadership.

## Supervision

There are many reasons to convince people that South Africa has a brilliant supervisory system. The two houses of Parliament of the South African government, which form the National Assembly (NA), and the National Council of Provinces (NCOP), have a specific supervisory role to play.

The Constitution states that the NA is elected to represent the people and to ensure government by the people under the Constitution. It does this by:

- Ensuring that all executive organs of state at the national level of government are answerable to it, and
- Maintaining oversight over the exercise of national government authority, and the implementation of legislation. (Parliament of South Africa)

The NCOP represents the provinces to ensure that provincial interests are taken into account in the national sphere of government.

- The NCOP's role is to exercise oversight over national aspects of provincial and local government.
- The NCOP may require a Cabinet member, an official of the national government. (Parliament of South Africa)

However, there is no measurement which can be referenced that could clearly show how the implementation of the South African government's supervision is at present.

The Communist Party of China Central Committee and the State Council issued the 'Decision of the Central Committee of the Communist Party of China and the State Council on the Acceleration of Progress in Science and Technology on May 6, 1995. The 'Decision' set the overall goal (both public and private) to attain Chinese R&D spending equivalent to 1.5% of

GDP by the year 2000. It urged scientific academies and institutes of higher education to set up high-tech companies. The 'Decision' noted that science and technology are the chief forces of social and economic development. The leadership pointed out population control, feeding the population, the environment and public health as problems for Chinese science and technology.

The 'Decision' called for a reform of the Chinese science and technology structure to meet the needs of the socialist market economy. Science should move out of the institutes into private enterprises. Government research institutes should enter into cooperative ventures with Chinese and foreign companies, decide by themselves what direction their research should take, and in so doing would not become responsible for whatever profits or losses they incur. The flow of personnel, information, and capital must become faster and smoother so that companies can orientate their research programmes according to market needs. (Science and technology in the People's Republic of China)

### **Establishing the number of Programmes**

The Technology for Human Resources for Industry Programme (THRIP) aims to increase participation by small, medium and micro-enterprises (SMMEs), Black Economic Empowerment entities and black and female researchers and students, as well as to expand the share of the THRIP budget allocation to historically disadvantaged individuals and universities of technology. THRIP supports, on average, 2 400 tertiary students each year. (South Africa Online)

The Tshumisano Technology Station Programme encourages advancing technology transfer and skills development to enhance equitable economic development. In this regard, the HE sector has a vital role to play in supporting SMMEs to become engines of growth. The Tshumisano Trust collaborates with universities of technology in particular to promote the development of industries in manufacturing, chemicals and textiles, and supports innovation within SMMEs and student skills' development. (South Africa Online)

South Africa has an advanced strategy which is called the Advanced Manufacturing Technology Strategy (AMTS). The AMTS guides efforts in the manufacturing sector, including the aerospace industry. It strives to:

- develop technology platforms that increase current efforts and to create new competitive advantages
- establish partnerships and human-potential development (South Africa Online)

The aim is to enhance the knowledge base and intensity of South Africa’s manufacturing sector. In the Department of Science and Technology’s Ten-Year Innovation Plan, the development of space S&T has been identified as one of the five priority areas.

Since the 1980s, China has formulated a series of national programmes for science and technology research and development, with the strategic aim of improving China's competitiveness in science and technology in the 21st century.

- Key Technologies Research and Development Programme
- 863 Programme
- 973 Programme
- S&T Programmes for Social Development
- National New Products Programme

The above are the key programmes that the Chinese government established to expedite S&T development.

### Summary

The evaluation of Government Leadership in the NISs of South Africa and China is conclusively presented in the table shown below:

Aspects	South Africa	China	Note
Initiate Strategy and Policy	Moderate	Good	South Africa was the first country in the world to adopt this framework as its national policy. The PRC government continues to play a central role in Chinese



<b>Aspects</b>	<b>South Africa</b>	<b>China</b>	<b>Note</b>
			science and technology development as well as in promoting high-tech industry innovation.
Supervision	Poor	Good	There is no measurement that can be referenced to show how the South African government implements supervision at present. The Chinese government set a goal to supervise the R&D development and control the factors that influence the R&D.
Establish No. of Programmes	Moderate	Excellent	South Africa has an advanced strategy which is called the Advanced Manufacturing Technology Strategy (AMTS) Many programmes were established in China to expedite S&T development.
<b>Overall</b>	<b>Moderate</b>	<b>Good</b>	
<b>Government Leadership</b>	<b>Weakness</b>	<b>Strength</b>	

Table 5.2 Summary of SWOT Analysis of Government Leadership

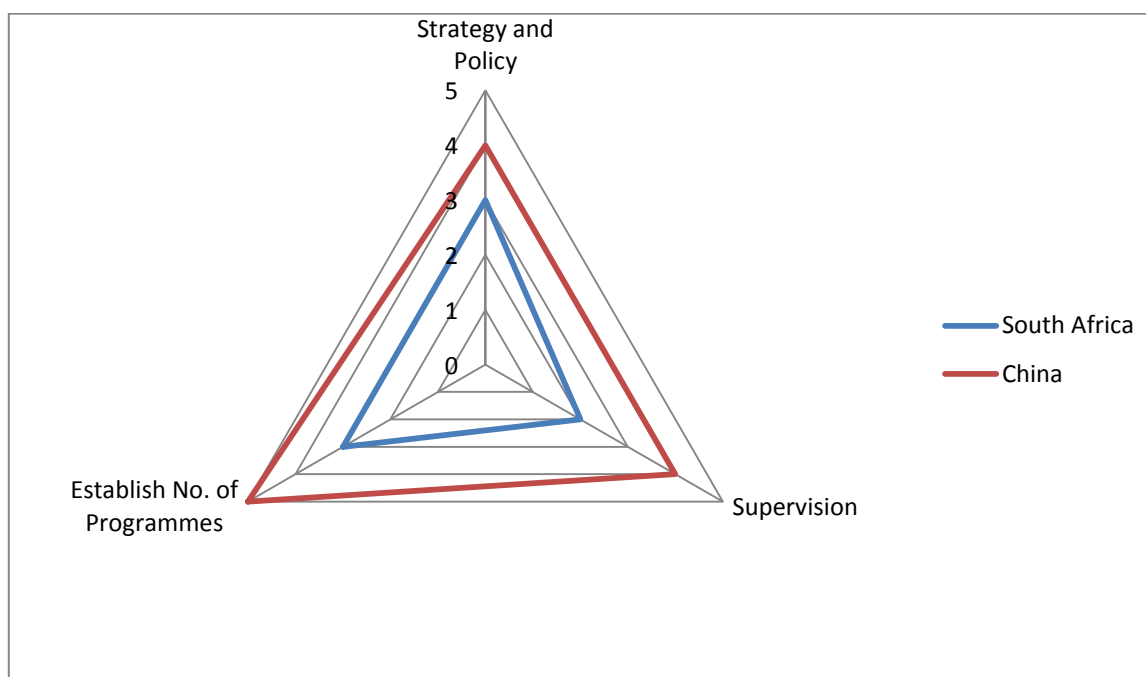


Figure 5.2 Radar Diagram of the Government Leadership

### 5.2.2 Strategy & Policies

Following the formation of the new government in 1994, the public mission of the apartheid era such as defence, energy and food self-sufficiency were largely abandoned. The new policies have sought to rationalise structures and actors in the R&D funding and performance system and to re-align priorities to address South Africa's overall social and economic development needs. (OECD, 2007)

A strategy of Invigorating the Country through Science, Technology and Education has been made and was published in 1995 as mentioned in Chapter 4. China is no longer happy to play the role of 'world factory'. The new economic growth of the People's Republic of China is all based on innovation-centred and sustainable development.

### Strategy to Enhance Innovation

The South African national R&D strategy rests on three pillars. The first pillar is innovation, which involves the establishment and funding of a number of technology missions, which are regarded as critical to promote economic and social development. These platforms are bio-technology, information technology, and technology for manufacturing, technology to leverage knowledge, technology from natural resources sectors and technology for poverty

reduction. It is added that this portfolio of missions needs to be managed in a coherent and integrated way, which initially will be the responsibility of the Department of Science and Technology. The second pillar, and connected to the first one, is the human resource development. The approach to this pillar is rooted in the need, on the one hand, to radically increase the number of people (especially women) from previously disadvantaged communities entering the scientific community and remaining there, and on the other hand, a strategy to maximise the pursuit of excellence in global terms. The National Research Foundation is seen as a key institution for this pillar. The third pillar aims at creating an effective government Science and Technology system, which implies attributing clear roles for governmental departments and ensuring that international best practice, with respect to state funding of science and technology, is accomplished. (Oerlemans & Pretorius, 2006)

Strategies for indigenous knowledge, nanotechnology, astronomy and intellectual property, derived from publicly funded research, have been developed. The innovation towards a knowledge-based economy plan aims to drive South Africa's transformation towards a knowledge-based economy in which the production and dissemination of knowledge lead to economic benefits and enrich all fields of human endeavour.

The analyses of the innovation strategy in South Africa reveal that there are many challenges to the national innovation system which require specific corrective measures. After an extensive process of public consultation and stakeholder reviewing, the Department of Environmental Affairs and Tourism (DEAT) has released a draft National Strategy for Sustainable Development (NSSD) that currently serves as a discussion document within a public consultative process. The 2006 Strategy looks forward 20 to 30 years, but will be updated regularly to ensure that the 20 to 30 year Vision and Action Plan remains hopeful, relevant and realistic.

For China, this section can be presented as two major parts as shown in the Chinese S&T development strategy. Firstly, it is the technology innovation system strategy. In the strategy, it emphasises the role of enterprise.

The main function of enterprises in the technology innovation system strategy must be

- The main role of R&D investment
- The main role of S&T activities
- The main role of S&T result application

The second strategy is the knowledge innovation system strategy. It emphasises

- A combination of S&T research and university activities
- An open, liquid, competitive, collaborative system
- Sustainable support to R&D facilities (Ministry of Science and Technology of China, 2006)

The key word in the Chinese innovation strategy is 'indigenous innovation'. In the report of CTIBO, the strategy clearly emphasised that Indigenous Innovation is the top mission for R&D development (Ministry of Science and Technology of China, 2006). In several fields, core technology must be developed and self-owned intellectual properties are to build a group of internationally competitive companies.

Outside observers tend to focus on the success story of an unprecedented growth policy documents, and recent domestic debates in China have pointed to the need for a shift in the growth trajectory with stronger emphasis on 'indigenous innovation' and 'harmonious development' (Gu & Lundvall, China's Innovation System and the Move Toward Harmonious Growth and Indigenous Innovation, 2008).

On the other hand, as mentioned in Chapter 4, China is no longer satisfied with the country's position as the world's manufacturer. The policymakers in Beijing are looking to strengthen China's economy towards a high technology basis. Their solution is to break China's dependence on foreign technology, moving from a model of "Made in China" to one of "Innovated in China."

### **Strategy to Develop Human Resources and Skills**

In the detail to develop South Africa's human resource, the South African Government has issued a Human Resource Development Strategy (HRD-SA) 2010-2030. This strategy

endeavours to provide a plan to ensure that people are equipped to participate fully in society in the next 20 years, to be able to find or create work and to benefit fairly from it.

The most important strategic priority for South Africa leading up to the government term of 2010 to 2030 relates, on the one hand, to the challenge of reconciling the immense opportunities that flow from their successes and, on the other hand, to the immense challenges arising from their country's development agenda. The peaceful transition to democracy, delivered through the commitment and forbearance of all South Africans, was followed by rapid gains in key areas of development, including:

- a favourable trajectory of economic growth;
- dramatic improvements in the delivery of social services, such as water and sanitation, housing and electricity;
- a dramatic increase in social grants; and
- a justifiable Bill of Rights. (September.P, 2010, p. 6)

A post-apartheid skills policy is expressed in the National Skills Development Strategy (NSDS) –now in its second re-iteration for the period 2005 – 2010, often referred to as 'NSDS II' – as well as the new institutional arrangements with which it is associated, namely the National Skills Authority, National Skills Fund and the Sector Education and Training Authorities (SETAs), established by the Skills Development Act of 1998. These are viewed by Kraak (2004 a: 117) primarily as an attempt to address incoherence in skills development and enterprise training activities. Learnerships, as the primary form of workplace training, aimed at providing workplace learning in a more structured and systematic form, together with the levy-grant system, which makes industry investment in skills development compulsory, are key elements of the new institutional arrangements. Most SETAs have specific skills development programmes for SMMEs. (Department of Trade and Industry, 2008)

In the year 2001, government adopted a human resource development strategy (promoted principally by the Ministers of Education and Labour) based on four pillars: general education, meaning compulsory schooling, early childhood development and adult basic education and training.

- ✓ The supply-side: meaning further education, training and higher education.
- ✓ The demand side: meaning the integration of employer requirements into formal education programmes in a systematic way.
- ✓ The National System of Innovation: meaning the close articulation of research in the higher education sector with the innovation requirements of the economy and society. (The Government of the Republic of South Africa, 2002, p. 59)

The HRD strategy is indicator based, and the research and development indicators match those put forward in this strategy. Furthermore, the new targeted approach for research funding in higher education is in the spirit of this R&D Strategy, which seeks to leverage scholarship and academic creativity in a focused way. (The Government of the Republic of South Africa, 2002)

China has a specific HRD strategy which has very high priority in government concerns (or ... priority as far as the government is concerned). The Chinese HRD strategy, in general, can be distinguished in 5 major parts:

1. Human Resource Investment Priority Strategy
2. Human Resource Value Realizing Strategy
3. Structure of Intellect Reform Strategy
4. Personnel System Reform Strategy
5. Personnel Development Strategy

There are some research projects indicating the problems existing in the Chinese HR Strategy that inflexible rules, poorly defined objectives, slow decision making, and a limited strategic role for HR managers need to be addressed. These matters are all related to key commercial and political issues facing firms in China such as improving selection, retention, and promotion methods within firms as well as external institutions, such as the rule of law. In other words, changes at the enterprise level are important, but significant changes are also required at the institutional level. (Ahlstrom, Foley, Young, & Chan, 2005)

## Strategy for Business Development

A number of new government policies have emerged to help South Africa to achieve the development strategy with a bearing on aspects of entrepreneurship and small business development.

Since the early years of empowerment, the South African government has highlighted the link between SMMEs and BEE, but only in recent years, the importance of small businesses for transformation has been emphasised. In his 2006 State of the Nation address, South African President Mbeki made particular reference to the importance of the small business sector for South Africa and its inevitable link with growth and the transformation process in the country. He noted that the Accelerated and Shared Growth Initiative of South Africa (ASGISA) is too fast track economic development and confirmed the need to expand the SMME sector, paying particular attention to the development of women and the youth and Broad Based Black Economic Empowerment (B-BEE). The SMME and BEE frameworks have been better aligned recently. On the one hand, the strategy for B-BEE highlights the importance of SMMEs in the transformation process. On the other hand, the national strategy for the development and promotion of small business identifies the creation of new black-owned and black controlled enterprises as a key issue. Similarly, institutions such as the NEF and the IDC were requested to serve both empowerment and SMMEs, and different programmes (i.e. the DTI's Small and Medium Sized Enterprise Development Programme and the Black Business Supplier Development Programme) and have aimed at fast-tracking the implementation of the BEE Strategy. (Sanchez, 2006)

Historically, China's industrial organisation has not been a product of market forces. Industrial enterprises in China were a creation of the pre-1979 Soviet style command economy. Enterprises were not really business organisations, but factory units under the active direct supervision of central and provincial government industrial bureaus. The SME sector in China was first allowed on the fringes of the economy, and was initially regarded as a supplement to the state and collective sectors. Faced with restrictions and biases, SMEs, at an early stage, had to establish close links with the local bureaucracy and operate under a high degree of informality. However, because of the decentralisation and strong

bureaucratic incentives to promote local development, the system was both flexible enough and sufficiently responsive to such a degree that it allowed for the cumulative development of SMEs. Yet, this has only been possible since the late 1970s (in agriculture) and the 1980s (in various manufacturing industries). (Kanamori, Lim, & Yang, 2007)

More current detail of SME strategies will be discussed in the section SME Enterprises in this chapter.

### **Policies of NIS**

In overall terms, South Africa pursued the right policies, and made the right policy choices. South Africa has pursued an “Africa first” policy which now has diplomatic representation in 46 of Africa’s 54 countries. By 2007, Africa had received more than any other region of the country’s R3282 billion per annum budget, reinforcing the country’s commitment to the continent and the African Agenda. (Landsberg, 2009)

The policy of The Black Economic Empowerment (BEE) has played an important role since. The BEE is one of the most important policies that involve the government of South Africa in the nation’s economy.

South Africa's policy of BEE is not simply a moral initiative to redress the wrongs of the past. It is a pragmatic growth strategy that aims to realise the country's full economic potential. In the decades before South Africa achieved democracy in 1994, the apartheid government systematically excluded African, Indian and coloured people from meaningful participation in the country's economy.

Criticism of black empowerment has also come from outside the investor community. Most South Africans believe something must be done to increase opportunities for all but they still view BEE as problematic. Some regard it as a form of discrimination, even "reverse racism". Hence the BEE policy is considered as a threat at the moment.

Presently another problem in NIS is that South African policies were made with a racial tendency that is trying to create jobs for non-white people and the labour law is over-protecting people who do not want to work but who still receive a salary.



The OECD document also points out that South Africa needs to increase the degree of specialisation and differentiation between functions within the vertical structure of governance. (OECD, 2007)

In the report of *The Evolution of the South African Science, Technology and Innovation System 1994-2009: An Exploration*, several conclusions were drawn from the preceding overview of policy developments since 1994. The following are thought to be relevant within the context of the present paper:

The liberation struggle brought a wide range of commitments, expectations and the role of STI

- The new role players in the democratic government were reasonably well prepared to take over government STI functions.
- The period up to approximately 2000 produced essential policy initiatives, but the implementation of them lagged behind.
- The policy initiatives were predominantly focused on the upper end of the innovation value chain – i.e. knowledge production – notwithstanding the original commitment to innovation.
- The primary focus within the innovation context was more on competitiveness than on development of the disadvantaged component of the population. (Marais & Pienaar, 2010)

In China, on the other hand, the technological innovation of enterprises to protect the laws and regulations is not perfect as described in Chapter 4. Since reform and opening its doors, China has formulated and implemented the "Scientific and Technological Progress Law" and the "Scientific and Technological Achievements Law" as well as other laws and regulations. The State formally implemented the "SME Promotion Law" in 2003, but compared with developed countries, China still has no uniform primary and secondary Enterprise basic law, which makes it difficult for SMEs to develop a special status. Individual characteristics of corresponding legal norms render it impossible for SMEs to provide equal competition, technological innovation and the legal environment lacks effective property rights incentives.

Details of SME development policies are presented in the Small and Medium Enterprises section.

## **Implementation**

In general, the South African S&T development was recognised as lying between the levels of developing and developed countries. Nevertheless, human resources were mentioned many times in the different reports as the key constraint, and it influenced the sector of strategies and policies by lack of professional political policy research and poor implementation.

Evaluation of the South African Science and Technology disclosed that the core of the South African STI (Science, Technology and Innovation System) missions had changed substantially over time. However, the implementation of such policy changes was uneven and tended to concentrate on the upstream part of the innovation value change, namely R&D and in areas such as space science. Furthermore, a key commitment to utilise STI for the benefit of the disadvantaged sections of the population as contained in the first policy document, namely the White paper on S&T, seems to have been neglected. (Marais & Pienaar, 2010)

The government in China centrally develops a series of S&T plans, and then uses these plans as a basis to allocate resources and assign R&D work to relevant institutes.

## **Summary**

After considering the above-mentioned factors, the strategies and policies made by South Africa are judged somewhere between the levels of strength and weakness. However, the threat of over-protection of non-white people and unskilled workers may cause a more seriously unbalanced problem. Therefore, the section about strategies and policies was evaluated as a threat to SWOT.

Summarily, the South African innovation strategy focuses more on the domestic demand, which means the demand for social development, unemployment and the alleviation of poverty. It is a strategy to solve existing social contradictions. The strategy matches the situation of South Africa's economic growth and other social problems at grass-roots level.

On the other hand, the Chinese innovation strategy has a higher aim. It is based on the global strategy and gives obvious ranking requirements which may not be necessary. The strategies are good. However, they would have been even better strategies if the purpose had not been to compete with other developed countries, but to really consider the country's demand. However, it also really shows the power of strategy-making.

An obvious strength in the Chinese Innovation System is that China has been concentrating government power on making policies that have aims, and which operators are able to use effectively. Because of the top-down approach, the efficiency of Chinese policies implementation is relatively high, but excessive levels of government reduce this efficiency.

Aspects	South Africa	China	Note
Strategies to Enhance Innovation	Good	Good	The innovation towards a knowledge-based economy plan aims to drive South Africa's transformation towards a knowledge-based economy. The key word in the Chinese innovation strategy is 'indigenous innovation'.
Strategies to develop HR & Skills	Good	Moderate	This strategy is trying to provide a plan to ensure that people are equipped to participate fully in society in the next 20 years, to be able to find or create work, and to benefit fairly from it. China has a specific HRD strategy that has a very high priority as far as the government is concerned, but is facing challenges.
Strategies for Business Development	Moderate	Good	The national strategy for the development and promotion of small business identifies the creation of new black-owned and black controlled enterprises as a key issue.
Policies for NIS	Moderate	Excellent	The BEE policy of South Africa

<b>Aspects</b>	<b>South Africa</b>	<b>China</b>	<b>Note</b>
			presents a massive threat to economic growth. China has formulated and implemented, a "Scientific and Technological Progress Law" and a "Scientific and Technological Achievements Law", including other laws and regulations
Implementation	Moderate	Good	The implementation of such policy changes was uneven and tended to concentrate on the upstream part of the innovation value change, namely R&D in South Africa. The top-down approach, the efficiency of Chinese policies implementation is relatively high, but excessive levels of government reduce this efficiency.
<b>Overall</b>	<b>Moderate</b>	<b>Good</b>	
<b>Strategy and Policy</b>	<b>Threat</b>	<b>Strength</b>	

Table 5.3 Summary of SWOT Analysis of Strategy and Policy

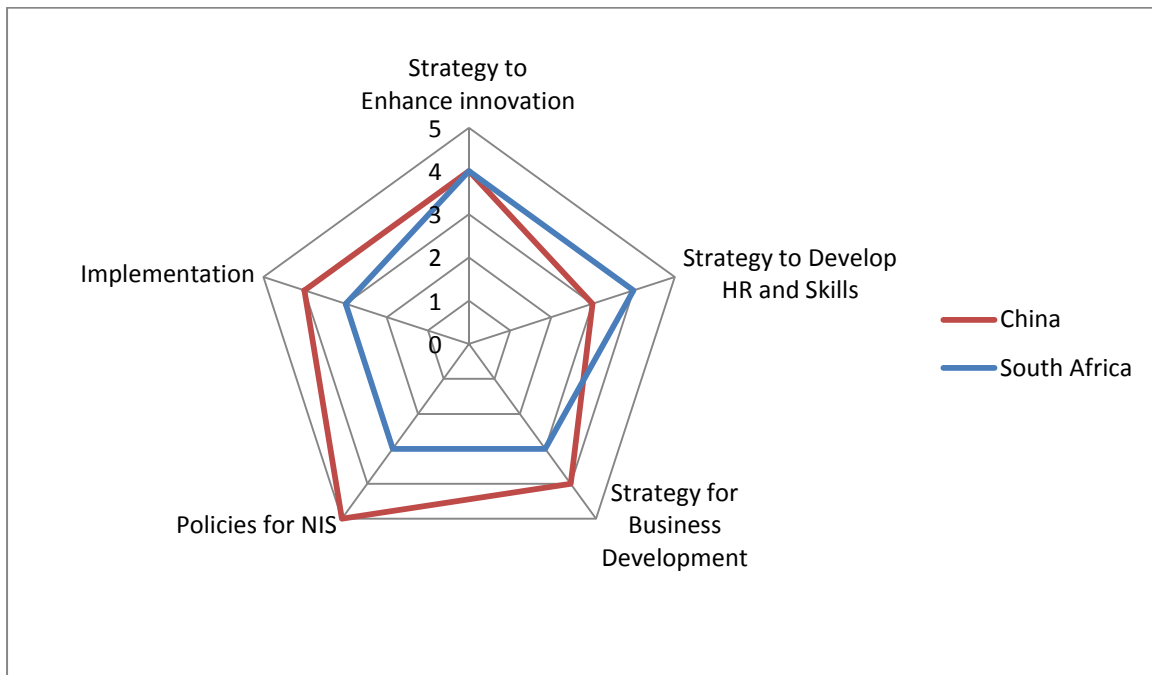


Figure 5.3 Radar Diagram of Strategy and Policy

### 5.2.3 R&D Expenditure

South Africa's large proportion of business enterprise expenditure on R&D is a virtue and reflects industry's ability to build on existing strengths, especially in resource intensive branches, and to develop a bigger cluster of capability. (Department of Science and Technology of South Africa, 2007)

One thing has to be considered in this sector, the South African economy is based on energy, agriculture and mining which are traditional industries that differ from communication and electronic products, as for example, in Finland's economy which was previously discussed.

### Gross Expenditure

A research project done by OECD in 2009 illustrated the R&D expenditures and is shown below:

Countries	Gross Domestic Expenditure on R&D-GERD (million PPP \$)	GERD as a percentage of GDP
Argentina	2317.144	0.495
Australia	15278.976	2.057
Austria	7171.265	2.467
Belgium	6598.975	1.863
Canada	23732.901	1.973
China	86692.51	1.417
Chinese Taiwan	16510.931	2.576
Denmark	4705.961	2.478
Finland	5918.717	3.45
France	41156.404	2.098
Germany	68475.984	2.528
Japan	138930.113	3.405
Netherlands	10782.353	1.776
Singapore	4725.833	2.265
South Africa	4100.868	0.947
U. Kingdom	36304.536	1.755
United States	347692.1	2.607

Resource: (OECD, 2009)

Table 5.4 Ranking of Gross Domestic Expenditure on R&D

According to the statistics, South Africa spent 4100.87 million dollars on GERD for research and development (R&D) in 2008. Another statistic from the Department of Science and Technology of South Africa showed that the country spent R18.6 billion, which represents an increment of R2.1 billion of the Gross Expenditure on R&D (GERD) compared to R16.5 billion in 2007. (OECD, 2009)

In China, 86692.51 dollars spent on GERD was used for Chinese R&D development in 2009. According to other data from the OECD report, the expenditure on research and development (R&D) reached RMB 461.6 billion Yuan in 2008. R&D expenditure in 2008 shared 1.44% of the GDP for the year. The government contributed 108.9 billion Yuan, which accounted for 23.6% of the total R&D expenditure; and enterprises contributed 71.7% of the total which was 331.2 billion Yuan, and higher educational institutes shared 8.8%. (Data Sources: OECD, 2009)

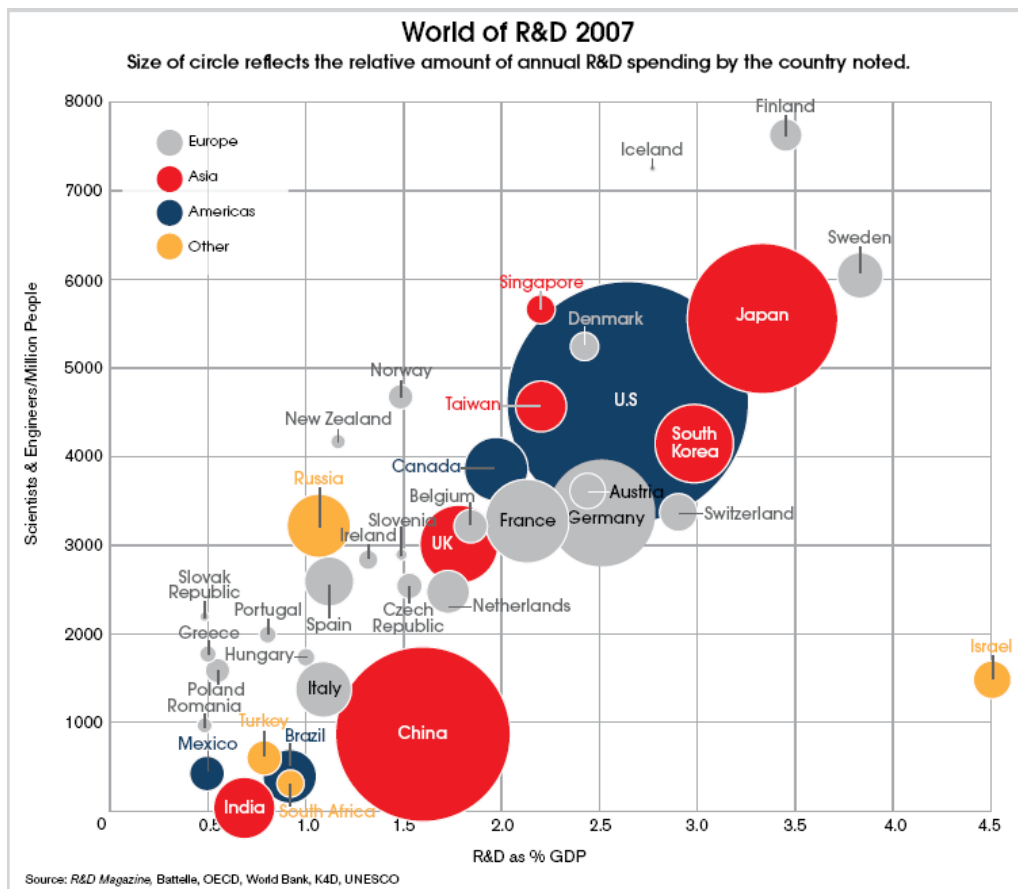


Figure 5.1 World of R&D 2007 (OECD, 2009)

A research study by OECD (See **Error! Reference source not found.**) shows that the total number of globally important patents originating from non-OECD economies is small compared to the OECD total, but the numbers have grown rapidly in recent years. In 1991, Brazil, China, India and South Africa accounted for 0.15% of the total share; by 2002 this had increased to 0.58% of the total (OECD, 2006).

Compared to Finland and the USA R&D expenditure, South Africa spent a smaller amount than Finland on R&D which showed \$5918.72. It indicates that South Africa does not have sufficient R&D investment from government to R&D, whereas China's R&D expenditure has no comparison with America, but is higher than most other countries except Japan. It shows good status in the gross R&D expenditure aspect.

### **Gross Expenditure per Capita**

To average R&D expenditure to the population, it is helpful to calculate the average ability of R&D. It is also an important figure to demonstrate the investment situation on R&D development.

According to the OECD statistics, China invested 69.3 billion dollars, divided by their population of approximately 1.3 billion. The gross expenditure per capita is about 53.1 dollar. Correspondingly, the South African R&D expenditure was 18.6 billion rand, which equals approximately 2.71 billion dollars. South Africa has a population of 49 million which equates the gross expenditure per capita to 55.3 dollar. (Data Sources: OECD, 2009)

The gross expenditure per capita of South Africa is relatively higher than China. However, in comparison, the United States had an average of 1,143,333 dollar gross expenditure per capita in 2006 and Finland reflected 1,301,887 dollar per capita in 2008. (Data Sources: OECD, 2009)

### **Percentage Expenditure of GDP**

The gross domestic product (GDP) per capita for South Africa was about USD 11 400 in 2004, which was on a par with many newly industrialised countries, although the average conceals huge social inequalities in income.

According to the analysis, the figure of R&D expenditure in China still indicates that a big gap exists compared to Finland, the USA and other developed countries. R&D expenditure took only 1.44% of GDP, as shown in Figure 5.1. It is hard to say whether China and, certainly, South Africa are high-tech nations. Although the total amount, because of the large GDP, is quite impressive, the average indicates that the investment per capita is still



not quite enough for many research studies and technology transfer processes. The VTT of Finland is a good textbook example for both South Africa and China to improve and rationally assign integrated resources.

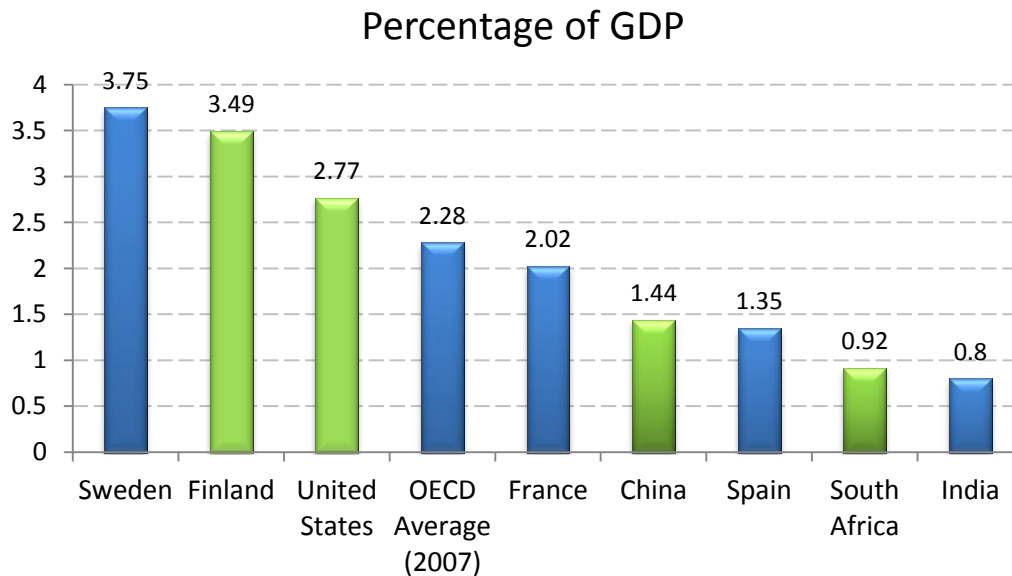


Figure 5.4 R&D Expenditure in percentage of GDP in 2008 (OECD, 2009)

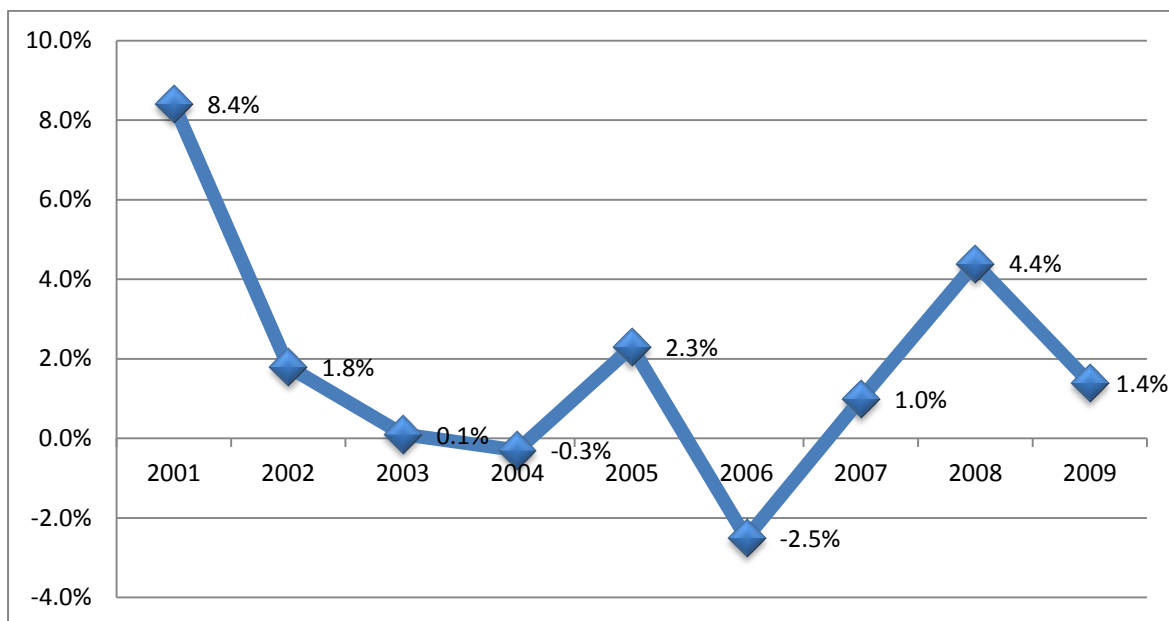
An official report shows that the South African total (public and private sector) expenditure on R&D amounts to approximately 0.8% (government 0.29%) of the GDP whereas the average OECD country expenditure is 2.28% of the GDP. Finland, for example, with an economy about the same size as South Africa, spends 3.49%.

Another report from the OECD states that companies spend about 1.8% of their sales revenue on innovation activities, moderate by OECD standards but still significant, especially given the importance of resource-based industry in South Africa's economy. (OECD, 2007)

China has an obvious advantage on the market, based on the immense population and healthy investment climate that is attracting lots of R&D investment into the country, which promotes local industries.

## Foreign Direct Investment (FDI)

Rather than focus on total inward investment, it may be useful to strip out and target net foreign direct investment (FDI) as a percentage of GDP, as shown in figure 5.5. This second indicator provides a completely different picture and clearly illustrates the strong influence of short term investment in overall investment flows. Looking specifically at FDI, foreign investment has in fact declined substantially from 8% in 2001 to just less than 2% in 2009, with net outflows recorded in some years. (UNDP, 2010)



Resource: (UNDP, 2010)

Figure 5.5 Foreign Direct Investment in SA as a percentage of GDP

The ability to attract foreign investment is important, given South Africa's savings rate, which is low compared to some other developing countries, especially those in Asia. South Africa's gross savings as a percentage of gross domestic products (GDP) was 14.8% in 2007, compared to countries such as China (54.1%). Gross savings, as a percentage of gross disposable income (GDI), indicates that South Africa's rate of saving has declined steadily for most of the last decade, before improving slightly in 2008 and 2009. (UNDP, 2010)

In the early stage of China's opening up, FDI inflow increased at a modest rate until the early 1990s. The realised value of inward FDI to China was \$3.49 billion in 1990, but soared to

\$27.5 billion in 1993. The figure reached \$37.5 billion in 1995 and peaked at \$45.3 billion in 1997 before declining to \$40.3 billion in 1999, largely due to the negative effects of the East Asia financial crisis. The volume of FDI inflow in 2000 was \$40.7 billion. (Cheung & Lin, 2004)

The number of foreign-invested R&D centres in high-tech industry sectors in China continues to rise, apparently rapidly. The latest statistics emanating from China's own studies of this phenomenon list the total number of foreign high-tech R&D centres in China at 750 (as of the end of 2004) (WALSH, 2005). China's statistics have varied widely over the past few years, with the most recent tally suggesting a one-year rate of growth of 200 new R&D centres in the 2003-04 period alone.

### Summary

China has great R&D investment, according to the research result, but the per capita figure showed a very negative result. Yet, it also indicates that China still has an increased capacity of R&D expenditure. While the economy grows, the country will have stronger ability to pay for more R&D expenditure.

South Africa, however, did not invest a lot of money in the R&D expenditure from government. One reason is that South Africa does not have so many government research institutes as China has. This will be discussed in 5.2.10. Moreover, the result of S&T development in the last ten years from South Africa will also give feedback concerning this aspect.

<b>Aspects</b>	<b>South Africa</b>	<b>China</b>	<b>Note</b>
Gross Expenditure	Poor	Good	South Africa: over R18.6 billion China: ¥ 461.6billion=\$ 69.3 billion both in 2008 U.S.: \$343 billion in 2006 Finland: € 6.9 billion in 2008
Gross Expenditure per Capita	Very Bad	Very Bad	Chinese gross expenditure per capita is about 53.1. South African gross expenditure per capita is 55.3 dollars. US gross expenditure per capita was \$1,143,333 in 2006 and Finland \$1,301,887 per capita in 2008.
Percentage Expenditure of GDP	Poor	Moderate	South Africa: 0.92% China: 1.44% U.S.: 3.49% Finland: 2.77% in 2008
Foreign Investment as a percentage of GDP	Poor	Excellent	South Africa's gross savings as a percentage of gross domestic products (GDP) was 14.8% in 2007, compared to countries such as China (54.1%).
<b>Average Credit</b>	<b>Poor</b>	<b>Good</b>	
<b>R&amp;D Expenditure</b>	<b>Weakness</b>	<b>Strength</b>	

Table 5.5 Summary of SWOT Analysis of R&amp;D Expenditure

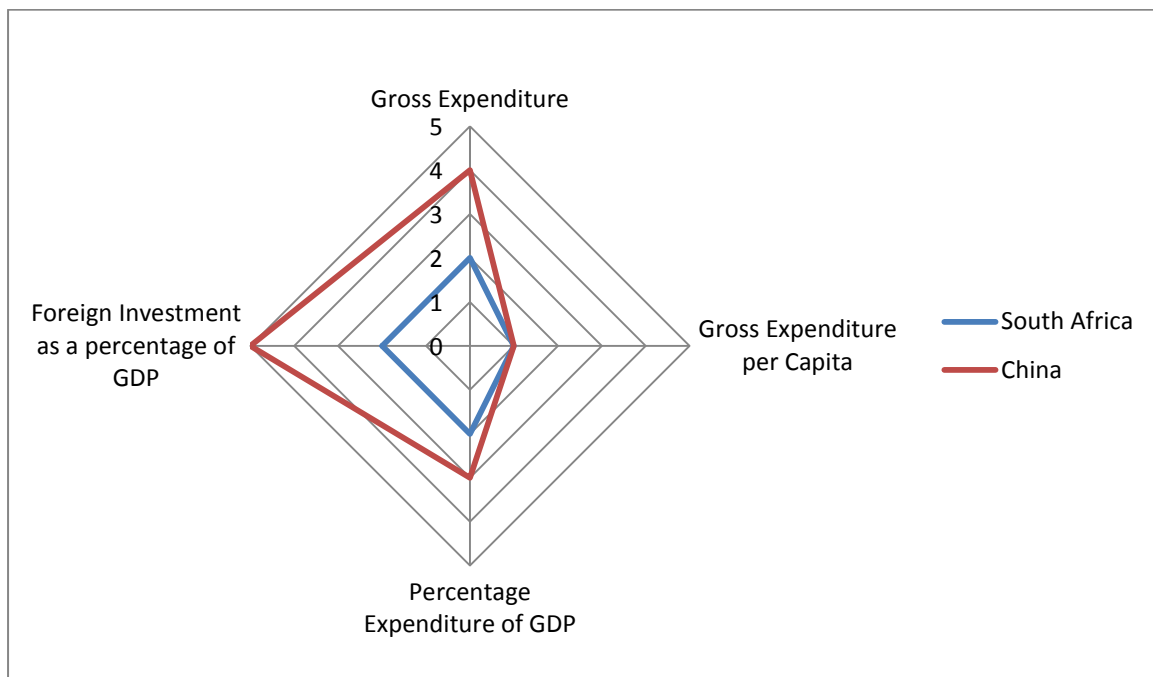


Figure 5.6 Radar Diagram of R&D Expenditure

#### 5.2.4 Human Resources

The South African government takes human resources as their national asset. The concepts of human resources development (HRD) refer to the process whereby people, either individually or collectively, acquire the knowledge and skills necessary for specific occupational tasks, as well as for the other social, cultural, intellectual or political roles associated with a vibrant democratic society (Department of Science and Technology of South Africa, 1996). However, the reality is that South Africa is facing a serious brain-drain problem, not only because of political reasons.

The large number of R&D personnel is one of the most important strengths for China in its S&T development. Human resources are at least as important as capital inputs and are a crucial building block in S&T development. The large number of R&D personnel is one of the most important strengths for China in its S&T development.

#### *FTE R&D Personnel*

According to the study in Chapter 4, in South Africa, with a total of 31,352 full-time equivalent (FTE) R&D personnel, there is a marginal growth of an already small quantity.

This category comprises researchers, technicians and other support staff. About 62% of these personnel comprise of 19,320 researchers or academically qualified people who perform, manage and guide the process of undertaking research that leads to new knowledge and novel research findings.

From 2000 to 2004, a sustained growth of R&D human resources in the eastern region, which is the most outstanding in science and technology activities in China, indicates that the total numbers of personnel in science and technology activities and R&D human resources increased, apparently, and the number of R&D human resources increased from 498,000 in 2000 to 700,000 in 2004. The eastern region of China has become the “highlight” of science and technology personnel. In 2006, China had the second highest number of researchers in the world, just behind the United States, and ahead of Japan and the Russian Federation.

Currently, the aggregate number of S&T professionals is 42 million in the country; the total of FTE R&D personnel is 1.9 million, ranking second globally. Finland has 40,900 FTE R&D personnel.

For the sake of comparison, it would be unfair to compare the total amount of FTE personnel between a country which has a population of 1.3 billion and another which has a population of only 49 million, even though the figures indicate how many people support the R&D development. Therefore, the calculation of each country’s FTE personnel divided by their population gives the result of the FTE personnel per capita. On average, South Africa has 0.64 FTE personnel for every 1000 people and China has 1.45 FTE personnel for every 1000 people. Accordingly, Finland has 7.71 FTE personnel for every 1000 people.

### **Personnel Attractiveness**

In recent years, the higher education sector in China has begun to attract a larger number of foreign students. In 2003, 34,000 foreign students graduated from higher education institutions in China, which was more than 10 times the number in 1991. In 2005, the number of foreign students who came to China for higher education, reached 141,087, which was more than ever before. Among them, 7,218 foreign students were funded by

Chinese Government scholarships, while 133,869 were self-supporting. More detailed information is needed, such as their country of origin, the subjects of their studies and the impact on the higher education system in China (Schaaper, 2009).

The purpose of that is not only for academic communication, but the government of China also realised that once people have studied in a certain country, they often stay there to start a career. The Chinese government use this phenomenon to attract more high-skilled labour to work in China.

### **Brain Drain**

Thousands of skilled young South Africans are continuing to emigrate in search of a better life, draining the country of much-needed economic resources.

However, the voice of disagreement also exists.

"The so-called brain drain in South Africa is finally showing signs of reversing, with indications that skilled graduate professionals who have left the country are beginning to show signs of returning home, and with fewer of those who do remain, choosing to emigrate." said by PPS CEO Mike Jackson (Prinsloo, 2010).

Furthermore, a research study is done by Crush and Frayne pointed out that most of very highly qualified respondents would be willing (32%) or very willing (32%) to take all their possessions out of South Africa (Crush & Frayne, 2010).

The opportunity to train more highly-educated personnel and solve the problem of a lack of higher education resources, the Chinese government encourages students to study overseas. The Ministry of Education of China estimated 134,000 students went overseas in 2007 and the number was more than 150,000 in 2008.

However, there is a problem that goes with the trend of studying overseas. According to the latest census data of the OECD, there were 718,000 highly skilled Chinese-born residents in OECD countries. 57% of them stayed in the U.S. and 18% in Canada, which presents a significant brain-drain problem to China's HR development.

## Summary

The final result of the human resource situation in South Africa and China is dramatically different. South Africa is facing an extreme lack of qualified workers, as well as brain-drain problems. This problem may potentially limit NIS development for years and drag the NIS development into a vicious circle. In this section, China is a good example for South Africa. To keep investing in education and the side industry, China is building a world-class academia and increasing attractiveness. The table below gives the analysed result of this section.

Aspects	South Africa	China	Note
FTE R&D Personnel	Moderate	Excellent	Total of 31,352 FTE R&D personnel in South Africa and the total of FTE R&D personnel in China is 1.9 million and ranked 1 <sup>st</sup> in the World. Finland has a total of 40,900 FTE R&D personnel.
FTE R&D Personnel per Capita	Very Bad	Poor	South Africa has 0.64 FTE personnel for every 1000. China has 1.45 FTE personnel for every 1000 people. Finland has 7.71 FTE personnel for every 1000 people
Personnel Attractiveness	Very Bad	Moderate	The number of foreign students who came to China for higher education reached 141,087.
Brain Drain	Very Bad	Very Bad	64% of very highly qualified respondents would be willing to take all their possessions out of South Africa. There were 718,000 highly skilled Chinese-born residents in OECD countries. 57% of them stayed in the U.S. and 18% in Canada
<b>Overall</b>	<b>Very Bad</b>	<b>Moderate</b>	
<b>Human Resources</b>	<b>Weakness &amp; Threat</b>	<b>Strength &amp; Threat</b>	

Table 5.6 Summary of SWOT Analysis of Human Resources



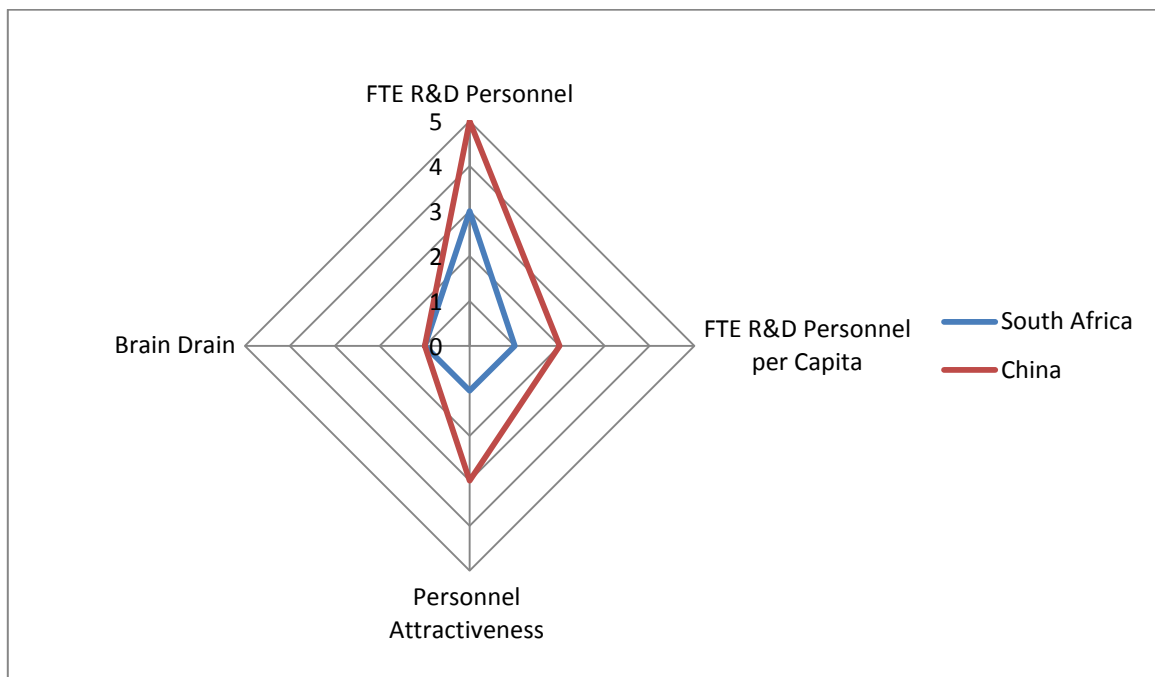


Figure 5.7 Radar Diagram of Human Resources

### 5.2.5 Higher Education

South Africa's higher education rate is not very high compared to the U.S. and China, but it does have very good educational resources and wide international cooperation. South Africa also widely popularised colleges to train the labour capabilities of people who need jobs. Summarily, South Africa has a very healthy and well-classified higher education system that can provide the necessary highly-skilled people to society.

China has adequate colleges and universities, which will help China to improve education and supply skilled people to society in future.

#### Number of Universities

There are 21 public universities, including 5 universities of technology in South Africa. Many of South Africa's universities are world-class academic institutions at the cutting edge of research in various spheres.

The South African higher education was restructured in 2005. A new type of institution, designed to cater for the merger of some universities with former "technikons", became comprehensive universities.

Even though education should be concentrating on more basic levels in South Africa, there is still a lack of universities to provide talents to society, especially, when South Africa is facing a large brain-drain problem.

China's current higher education system was largely shaped by the history of the last 50 years since the founding of the People's Republic of China in 1949. During this period, two opposing forces have played an important role in the formation of the current system, the centralised Soviet education model and the informal Chinese education model. The working of these two forces generated the current two overlapping systems: the regular higher education system and adult higher education system. Both systems were administered by central ministries and provincial or municipal governments. Only in recent years have private higher education institutions begun to emerge. By the end of 2004, China had 2,236 colleges and universities, with over 20 million students enrolled.

### Higher Education Enrolment and Graduation

The higher education (HE) enrolment and graduation shows the future capacity and capability of R&D development. It is a very important index to indicate the potential of a country's R&D development. This sector has only discussed HE graduations in both South Africa and China. The reason for this is that graduate students are to some extent shaped or matured personnel that contribute directly to society so that they can be classified into human resources.

Year	Total Enrolments	Total Graduations
2004	744,474	117,205
2005	735,070	120,375
2006	741,020	124,620
2007	761,084	126,641
2008	799,387	133,063

Source: Department of Education, HEMIS

Table 5.7 HE Enrolment and Graduation in South Africa

Year	Total Enrolments	Total Graduations
2004	2,099,151	1,196,290
2005	2,363,647	1,465,786
2006	2,686,448	1,726,674
2007	2,820,971	1,995,944
2008	3,074,741	2,256,783

Source: Ministry of Education of PRC

Table 5.8 HE Enrolment and Graduation in China

According to Table 5.7 and Table 5.8, the status of education development of South Africa and China is shown below.

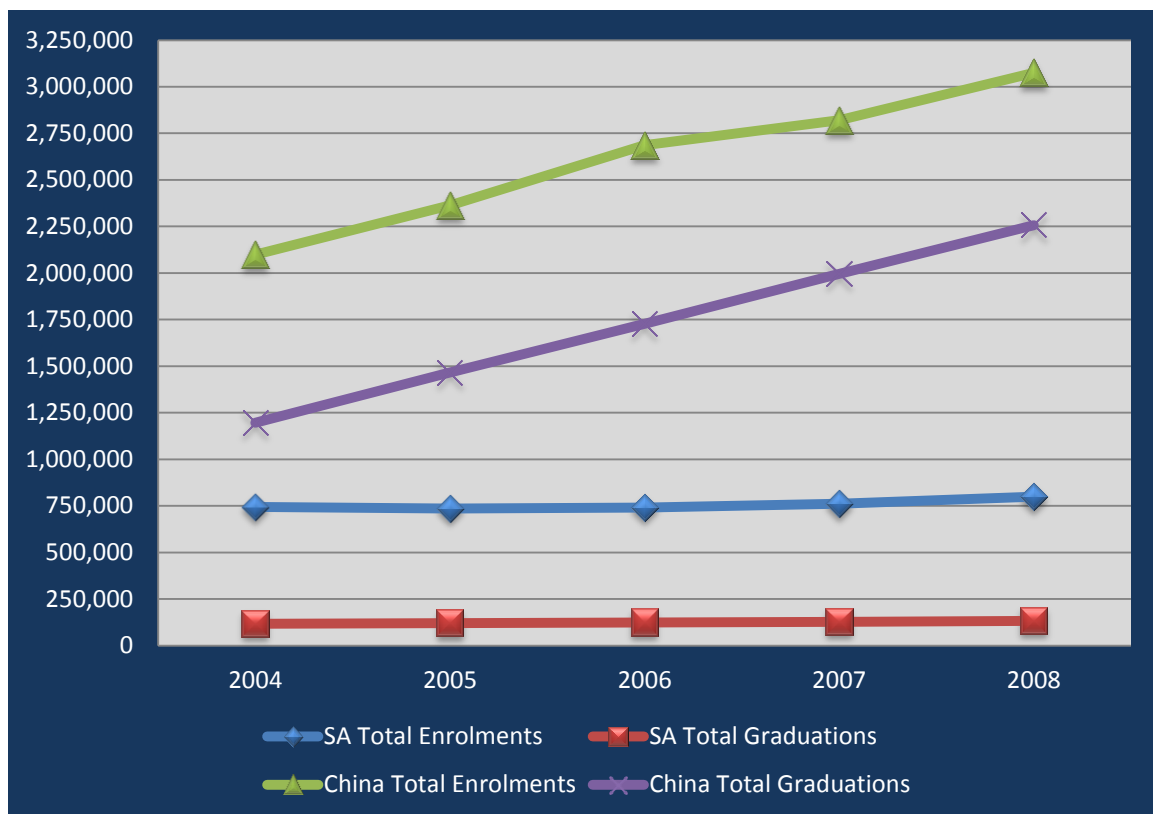


Figure 5.8: Comparison of HE Enrolment and Graduation

The increment of university enrolment directly indicates how many personnel can be conveyed into society after 3 or 4 years of university studies. No matter the number or the increment, China revealed a better situation than South Africa in the sector of enrolment.

That also indicates that there are policies supporting universities in China increasing the number of student enrolment, so that more students would have the chance to accept higher education. This replicates one of the national strategies of China as I previously mentioned.

An alternative method of comparing higher education enrolment and graduation, without considering the size of a country, is to divide the HE enrolment and graduation population of each country by its population. The result for South Africa is 1.62 per 100 people enrolled for higher education and 0.24 per 100 people enrolled in China. In South Africa 0.27 per 100 people graduated and 0.17 per 100 people graduated in China in the same year.

### **University Rankings**

According to the QS World University Rankings 2010, only two South African universities are listed in the top 300, the University of Cape Town listed as the best university in South Africa and ranked at 161 and the University of Witwatersrand ranked at 360. The University of Pretoria's overall ranking is 451 to 500 in the world. (QS, 2010)

China has five universities ranked in the top 100. The University of Hong Kong is the best university in China, ranked at 23, the Hong Kong University of Technology and the Chinese University of Hong Kong ranked at 40 and 42. Peking University is 47th on the list as the best university in mainland China and Tsinghua University ranked at No. 54 also from mainland China. Fudan University, which is located in Shanghai, ranked at 105, the City University of Hong Kong ranked 129. Shanghai Jiao Tong University and the University of Science and Technology of China each located at 151 and 154 respectively. The Hong Kong Polytechnic University shared No. 161 with Universität Karlsruhe in Germany. Nanjing University and Zhejiang University also ranked in the top 500 universities in the world (QS, 2010). These statistics didn't include universities in Taiwan as Chinese universities.

### **Summary**

South African higher education, generally, is world class in quality. But the ability to provide sufficient personnel is competitively weaker than China's higher education. Moreover, some factors for causing the problem are not only relative to the basic and high school education

system, but also to the policies of government and cultural influence. Consequently, South Africa and China have their own advantages and disadvantages. Generally, China has a stronger performance in this aspect.

The table below gives the analysis result of Higher Education aspect.

<b>Aspects</b>	<b>South Africa</b>	<b>China</b>	<b>Note</b>
Number of Universities	Poor	Excellent	21 public universities including 5 universities of technology in South Africa and 2,236 colleges and universities in China.
Higher Education Enrolment	Good	Good	In 2008, there were 799,387 students enrolled in South Africa and 3,074,741 students in China
Higher Education Enrolment % of Population	Poor	Very Bad	1.63 Per 100 people in SA and 0.24 per 100 people in China.
Higher Education Graduation	Moderate	Good	In 2008, there were 133,063 students who graduated in South Africa and 2,256,783 students graduated in China
Higher Education Graduation % of Population	Poor	Poor	0.27 Per 100 people in SA and 0.17 per 100 people in China.
World Top 500 Universities	Poor	Moderate	South Africa has 3 universities and China has 12 listed.
<b>Overall</b>	<b>Moderate</b>	<b>Good</b>	
<b>Higher Education</b>	<b>Weakness &amp; Threat</b>	<b>Strength &amp; Opportunity</b>	

Table 5.9 Summary of SWOT Analysis of Higher Education

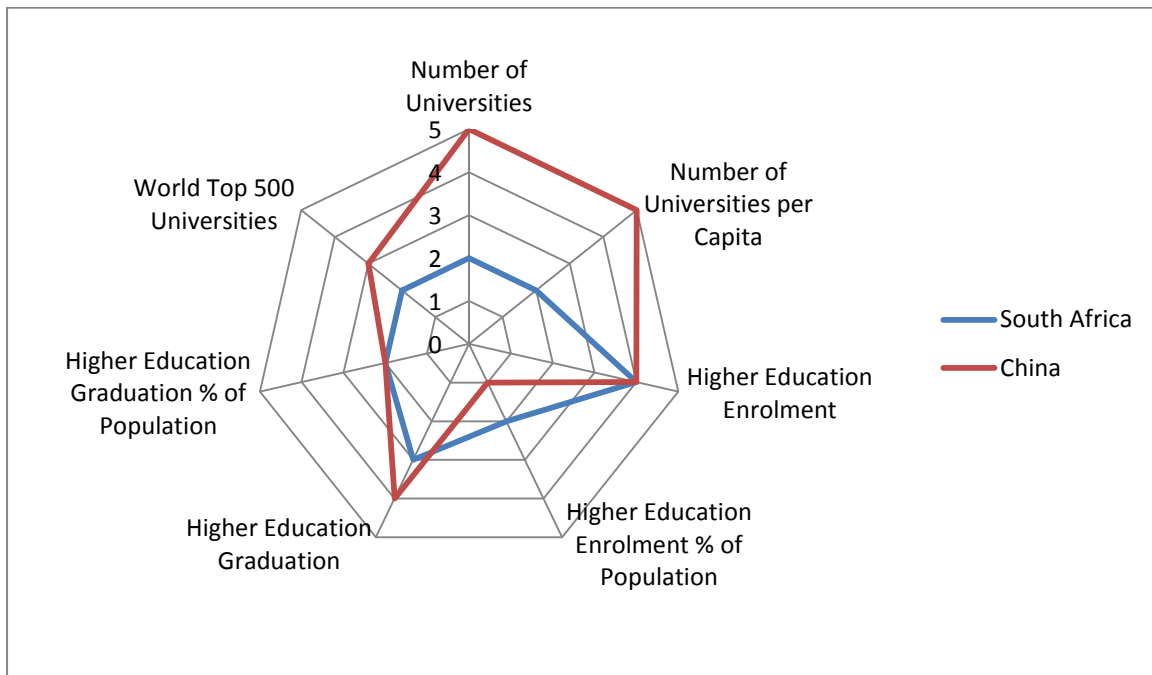


Figure 5.9 Radar Diagram of Higher Education

### 5.2.6 Science and Technology Development

South Africa is a middle-income country with an abundant supply of resources, is financially well-developed and has legal, communication, energy, and transport sectors. The technology development of South Africa is mainly achieved in the mining and energy fields.

China is a country which aspires to build a high-technology nation. Science and technology development in China have grown rapidly. It is commonly agreed that in the early 21<sup>st</sup> century, the gap in high-technology research and development between China and the world's advanced countries has shrunk; 60 per cent of technology, including atomic energy, space programmes, high-energy physics, biology and computer and information technology have reached or are close to the world's advanced level (Science and technology in the People's Republic of China).

#### Papers Published and Invention Patents

The report from R Sooryamoorthy shows that South African engineers produced a total of 2,036 scientific publications over the seven sampled years of analysis. In 1975 there were 86 publications; by 2005 these had risen to 574, an increase of more than six times.

(Sooryamoorthy R. , 2010) According to the research in Chapter 4, South Africa had 7740 patents granted in 2008 and 7205 patents granted in 2007, an increase of 7.4% during that year.

On the other hand, the production of scientific papers in South Africa as a whole (in all subjects) was not as rapid as in engineering research. Of the total 18,466 publications generated by South African researchers during this period, the increase from 1975 (1,212) to 2005 (4,161) was only three-fold. (Sooryamoorthy R. , 2010)

Another advantage of Chinese NIS is the technology and science development. According to an OECD research report, in 1996, the first year of the analysis, the US published 292,513 papers, which was 10 times more than China's 25,474. By 2008, the US total had increased very slightly to 316,317 while China's had surged more than seven-fold to 184,080. In the same year, China granted a total of 93,706 invention patents, compared to the No.1 invention granting country, America, where 157,772 invention patents were granted in 2008. Compared with South Africa, this seems excellent.

In contrast, China granted a total of 93706 invention patents in 2008 and ranked second in the world. While innovation by domestic entities is driving China's patent boom, China is also expanding its IP protection overseas. From 2007-2008, the growth rate of China's overseas patent filings in Europe, Japan and the U.S. were 33.5%, 15.9% and 14.1%, respectively. (Resource: Ministry of Science and Technology of China)

To compare the papers published per capita, the total publications are divided by each country's population. The result is 0.38 publications per 1000 people for South Africa and 0.12 publications per 1000 people in China.

Correspondingly, to compare the invention patents per capita, the total invention patents are divided by each country's population. The result is 0.15 patents per 1000 people in South Africa and 0.07 patents per 1000 people in China.

## Important Achievements

China has also achieved great success during the last 10 years. According to the introduction of Chapter 4, 60 per cent of technologies, including atomic energy, space programmes, high-energy physics, biology and computer and information technology, have reached or are close to the world's advanced level. Meantime, China has produced some big achievements such as a manned spacecraft, a 4<sup>th</sup> generation fighter aircraft, and high-speed railways, Maglev wind power generators, synthesis of crystalline bovine insulin, TianHe interconnect supercomputing and so on. This was hard for South Africa to compete with in the 21<sup>st</sup> century and late 20<sup>th</sup> century.

The most famous South African science and technology achievements include the Sasol oil from coal refinery, the heart transplant by Chris Barnard, the Kreepy Krauly swimming pool vacuum cleaner, etc., however, these inventions can only demonstrate the S&T development achievements in the middle of the 20<sup>th</sup> century. Since the 21<sup>st</sup> century, big technology surprises from South Africa have been rare.

## Summary

The S&T technology development is an important indicator showing the output of the NIS. The result of this discussion is motivated in the conclusion tabulated below.

Aspects	South Africa	China	Note
Papers Published	Poor	Excellent	184,080 publications were generated in China in 2008 and 18,466 by South African researchers.
Papers Published per Capita	Moderate	Poor	0.38 publications per 1000 people in South Africa and 0.14 publications per 1000 people in China.
Invention Patents	Poor	Excellent	In South Africa 7740 patents were granted in 2008, 93,706 invention patents were granted in China in 2008 which was ranked second in the world.



<b>Aspects</b>	<b>South Africa</b>	<b>China</b>	<b>Note</b>
Invention Patents per Capita	Poor	Very Bad	0.15 patents per 1000 people for South Africa and 0.07 patents per 1000 people in China.
Development Growth	Very Bad	Excellent	South Africa gained 7205 patents in 2007 and 7740 patents were granted in 2008, an increase of 7.4%. China's published academic papers surged more than seven-fold to 184,080 in 12 years. From 2007-2008, the growth rate of China's overseas patent filings in Europe, Japan and the U.S. were 33.5%, 15.9% and 14.1%, respectively.
Important Achievement	Poor	Excellent	China invented or innovated manned spacecraft, 4th generation fighter aircraft, and high-speed railways, Maglev wind power generators, synthesis of crystalline bovine insulin, TianHe interconnect supercomputing etc. South Africa has had rare competitive inventions in the 21st century.
<b>Overall</b>	<b>Poor</b>	<b>Good</b>	
<b>Science and Technology Development</b>	<b>Weakness</b>	<b>Strength</b>	

Table 5.10 Summary of SWOT Analysis of S&amp;T Development

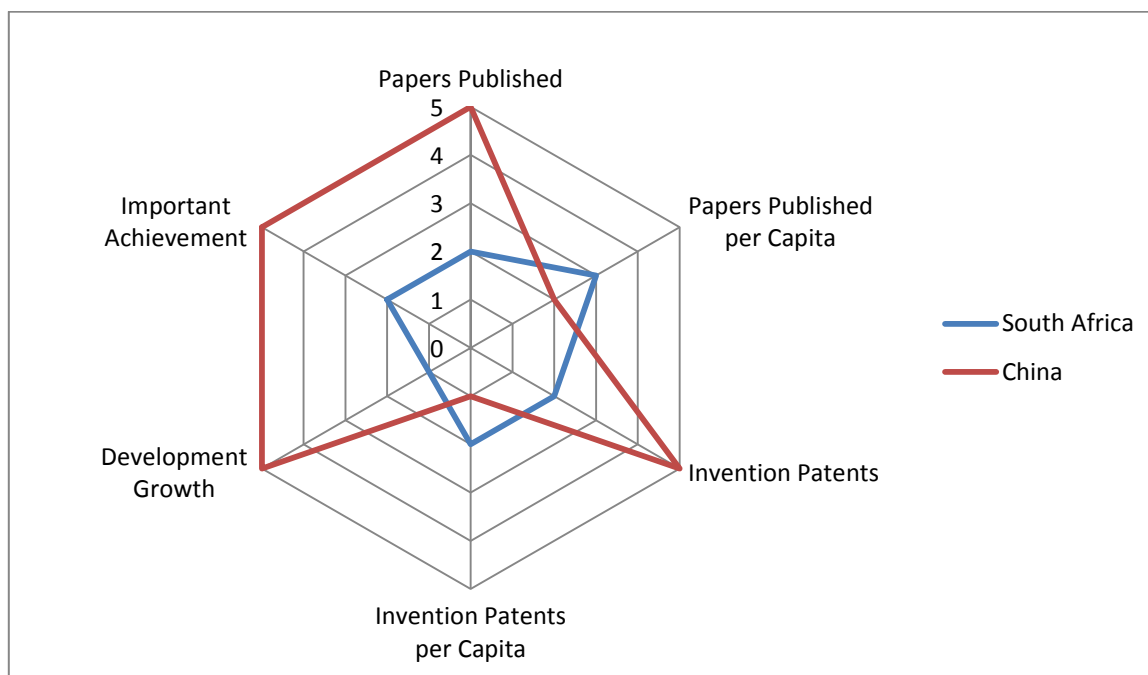


Figure 5.10 Radar Diagram of S&T Development

### 5.2.7 Paper Citation and Impact Factor

This section referenced ISI Essential Science Indicators to indicate the paper citation which is an impact factor of South African and Chinese S&T output through the journals.

#### Citations of Publications

According to the ISI essential Science Indicators, South Africa had 188,685 citations in 2005, ranked 33rd out of 152 top performing countries. On the other side, among the 145 top-performing countries in all fields, the People's Republic of China ranked 6th for citations, 13th for papers and 117th for citations per paper. The tables below contain rankings and citations for South Africa and China.

	Citations	Citations per Paper
<b>South Africa</b>	Rank (out of 152 countries)	33
	All fields <sup>2</sup>	188,685
		71
		4.91

<sup>2</sup> All Fields: stand for total numbers of citations in all fields.

		Citations	Citations per Paper
China	Rank	6	117
	All fields	1,718,847	3.86

*Resource: Essential Science Indicators from the July 1, 2007 update covering a 10-year plus 4-month period, 1997-June 30, 2007.)*

Table 5.11 10 years citations statistic for South Africa and China

Another visibility that suggests the S&T development is the number of citations per paper. The published report of R Sooryamoorthy argued that the Engineering publications of South African authors have earned an average of 5.2 citations per publication in the last 30 years. Omitting the year 2005, the count reduced to 4.25 in 2000. This is just 41% of the citations received in 1975 (Sooryamoorthy R. , 2010).

Due to language limitations, Chinese citations are apparently not frequently referenced by other non-Chinese countries, which is an external cause. Moreover, the internal cause of China having low citations per paper is that Chinese S&T development pursues the number of papers published, rather than the quality.

### Impact Factor

*Journal Citation Reports (JCR®)* offers a systematic, objective means to critically evaluate the world's leading journals, with quantifiable statistical information based on citation data. By compiling articles' cited references, *JCR* helps to measure research influence and impact at journal and category levels, and shows the relationship between citing and cited journals.

The JCR from Thomson Reuters provides quantitative tools for ranking, evaluating, categorising, and comparing journals. The impact factor is one of these; it is a measure of the frequency with which the "average article" in a journal has been cited in a particular year or period. The impact factor is a very useful tool for evaluating the journals which is the reason that this section used the impact factor angle to evaluate the situation of South Africa's and China's S&T development.

According to the Journal Citation Reports (JCR), the journal has a 2009 impact factor of 0.506 for South Africa. Today, in the People's Republic of China, there are more than 8,000 academic journals, of which more than 4,600 can be considered scientific. In 2008, China had an impact factor of 0.736, ranked at No. 8 in the world. (Thomson Reuters, 2008; The Government of the Republic of South Africa, 2002) The impact factor increased to 0.957, still ranking 8<sup>th</sup> out of 44 countries in 2009. (Thomson Reuters, 2009)

Moreover, the journal statistics of the JCR (Journal Citation Report) shows that South Africa has 33 scientific journals on the list and China has 138 journals on the list at present. Consequently, China has had a better impact on the citation and journals than South Africa. However, compared to the US, which has 2697 journals, both China and South Africa feature a low point. On the other hand, Finland as an innovative country has only 14 journals listed on JCR. (Data Resources: (Thomson Reuters, 2010))

### Summary

South African has better quality international publications for international researchers. Although the average citations of a publication have decreased as Sooryamoorthy commented, it is still more competitive if compared to Chinese average citations.

China has a great number, on the other hand. But the quality of publications and the Chinese language hindered the number of citations. However, Chinese journals have greater impact than those of the South Africans.

Aspects	South Africa	China	Note
Citations of Publications	Moderate	Poor	South African authors have earned an average of 5.2 citations per publication in the last 30 years. Citations of Chinese journals covered by the Science Citation Index were 0.326 in 1999. The total number ranked No.8 in the world in the last 10 years.
Citations of Publications per Paper	Moderate	Poor	South Africa has an average of 4.91 citations of publications per paper, and China has 3.86 citations of publications per paper
Impact Factor	Moderate	Good	South Africa had an impact factor of 0.506 in 2009 and China had 0.957 ranking 8 <sup>th</sup> in the same year.
Journals listed on JCR	Moderate	Good	South Africa has 33 journals listed on JCR and China has 137 journals. Compared to the USA's 2697 and Finland's 14 journals.
<b>Overall</b>	<b>Moderate</b>	<b>Moderate</b>	
<b>Paper Citations and Impact Factor</b>	<b>Opportunity</b>	<b>Strength</b>	

Table 5.12 Summary of SWOT Analysis of Paper Citations and Impact Factor

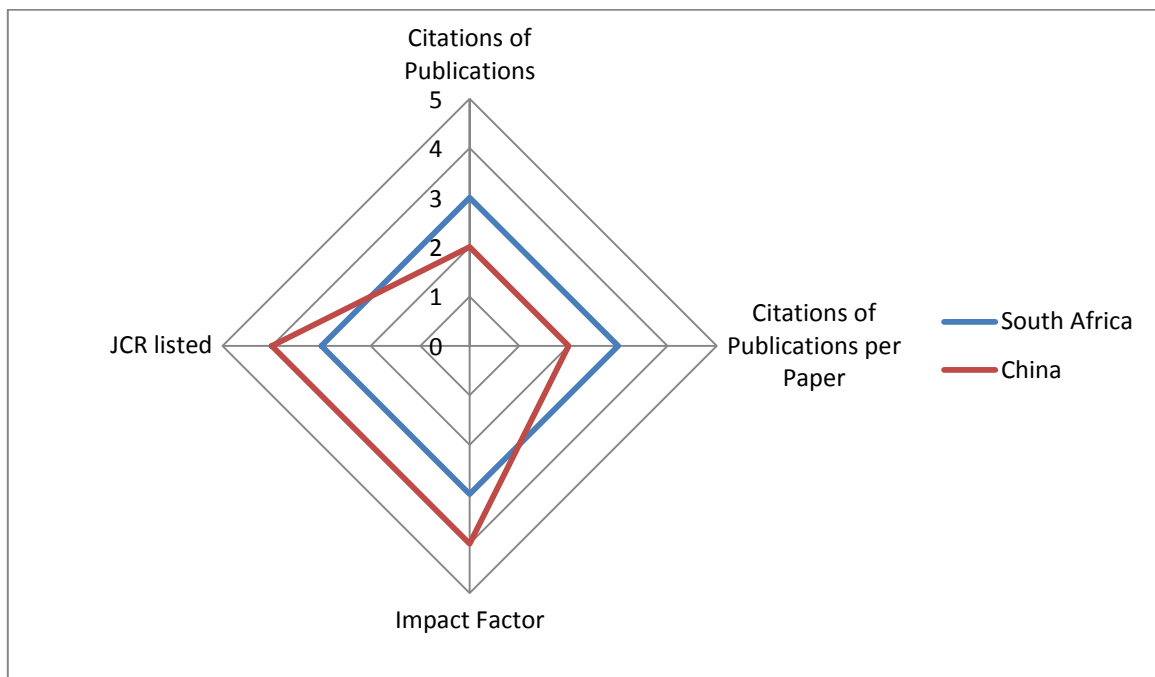


Figure 5.11 Radar Diagram of Paper Citations and Impact Factor

## 5.2.8 Intellectual Property Right Protection

### IP Policies

The South African intellectual property right protects the works of a writer, artist, or photographer. Although registration is not required, knowing how the protection works, and what limitations there are, is extremely important to prevent infringements of copyright. It falls under the regulation of the Copyright Act 98 of 1978.

South Africa makes provision for intellectual property protection according to four categories:

- Patents
- Designs
- Trade marks
- Copyright.

The former attempts to define the rights of South Africa in intellectual property, derived from publicly financed research by stipulating a number of rights in different conditions, as

well as providing for the establishment of dedicated funds to finance and secure intellectual property. The latter policy framework emulates the Bay Dole Act, as it seeks to provide the promotion of the development and the exploitation in the public interest of the discoveries, inventions, innovations and improvements. However, actors of technology transfer have subjected both initiatives (policies) to arguments and requirements to practical tests on implementation of such policies.

In the White Paper issued in 1996 on science and technology, the Department of Arts, Culture, Science and Technology raised the issue of South Africa “not being a patent examining country” as a significant shortcoming (Department of Science and Technology of South Africa, 1996). To date, this situation has not changed. The alleged sophistication of the South African intellectual property regime is clearly relative.

In fact, South African inventors with priority registration in the South African Patent Office secure around 100 United States patents per year. This represents 2.5 patents per million of the population per annum. This number is low in comparison to the developed world. Countries like Japan secure some 776 patents per million of the population per annum. The differences in patent rates between the developed and the developing world represent one of the greatest “divides” of the knowledge age (The Government of the Republic of South Africa, 2002). Since patents represent (with copyright), one of the strongest forms of “intangible value”, this is evidence of a weakness in South Africa’s ability to become a knowledge based economy.

At present, South Africa has no formal policy framework for intellectual property protection of publicly financed research. One of the consequences of this is considerable uncertainty (among institutions and individuals) about intellectual property rights and their management, particularly when the research is publicly financed.

The General Principles of the Civil Law of the People's Republic of China were adopted at the fourth session of the Sixth National People's Congress on April 12, 1986, with effect from January 1, 1987 (The Central People's Government of PRC, 2005). In this legislation,

intellectual property rights as a whole were clearly defined in China's basic civil law for the first time as the civil rights of citizens and legal persons.

Since 1985 when the Patent Law was launched intellectual property rights have developed vibrantly in China. However, the Patent Law only weakly protects the rights of intellectual property, especially in regard to some foreign high-tech companies.

New Chinese policies prompted by the report have raised the hackles of foreign governments and technology enterprises. In 2009, for example, China's government, a massive consumer of high-tech products, announced that in order to be a recognised vendor in the government's procurement catalogue, a company would have to demonstrate that its products included local innovation and were free of foreign intellectual property. Yet, since R&D is a global, collaborative process, no individual high-tech product is completely independent of technology from outside of China. In April 2010, Beijing ordered those high-tech companies seeking to be listed on its procurement catalogue to turn over the encryption codes of their smart cards, Internet routers, and other technology products.

Senior Director for Greater China at the U.S. Chamber of Commerce, Jeremie Waterman, testified before the International Trade Commission in June, that a weak legal environment allows Beijing to "intervene in the market for IP and help its own companies 're-innovate' competing IPR as a substitute to foreign technologies." (Segal, 2010)

## Copyright

South African copyright law was regulated wholly by the Copyright Act 98 of 1978<sup>3</sup>. Copyright Protect aims to offer proof of the existence of a specific file, script, design, literary, musical or literary work at a specific time and date. The extent includes drafts, working files, revisions, concept drawings, etc.

Tong (2009) commented in his research that while the South African government is bound to its TRIPS obligations and the pressures from developed countries; a difficulty lies in being

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<sup>3</sup> Copyright Act 98 of 1978, commencement date 1 January 1979



able to balance the needs of a developing country with the need to be part of the global trade regime. It seems, however, that until an alternative to proprietary software becomes the norm, the prevailing approach of private rights to protect proprietors will continue (Tong, 2009).

The Copyright Law of the People's Republic of China was adopted by the 15th meeting of the Seventh National People's Congress Standing Committee on September 7, 1990, with effect from June 1, 1991. That was 12 years after South Africa had started using the law to protect copyright. The purpose of the law described is to protect the copyright of authors in their literary, artistic and scientific works and also the copyright-related rights and interests, of encouraging the creation and dissemination of works, which would contribute to the construction of the socialist, spiritual and material civilization, and of promoting the development and prosperity of the socialist culture and science (The Government of the People's Republic of China, 1990).

The Chinese governmental copyright protection institute is called the Copyright Protection Centre. The role of this association is approximately the same as the CIPC's (Companies and Intellectual Property Commission) role in copyright protection in South Africa. This centre is an institution directly under the General Administration of Press and Publication (National Copyright Administration of China) and it was established in September 1998 with the approval of the State Commission Office for Public Sector Reform. As an institution which was set up by the state to provide copyright public services, the Centre plays important roles in enforcing the copyright laws, implementing the copyright administrative system, executing the national copyright strategy, developing and improving China's copyright public service system, safeguarding the right holders' legitimate rights, facilitating the creation and dissemination of all types of works, supporting the copyright industry's healthy development, boosting the capacity for independent innovation and turning China into an innovative country.

In reality, one issue that was raised by an American official, who visited China, was China's lack of copyright protection, especially in information technology. Chinese companies and

underground organisations pirate goods at such an alarming rate that Microsoft's CEO is quoted as calling it as being "sky high." (Fish, 2010)

However, Chinese providers are also suffering, due to violation of the copyright just as much as western firms in China. In reality there are a large number of news media websites infringed on by commercial websites. The phenomenon shows that the current copyright law in China is far behind in judicial practice.

### **Patent for Inventions**

South African criteria for invention originality are similar to those of most of the First World, such as Europe, the USA and Australia. The South African Patents Law was regulated by the Patents Act No. 57 of 1978<sup>4</sup>.

A patent is an exclusive right granted for an invention. The CIPC states that a patent is a product or a process that provides a new way of doing something, or offers a new technical solution to a problem. The patent provides protection for the owner, which gives him/her the right to exclude others from making, using, exercising, disposing of the invention, offering to dispose of, or importing the invention. The protection is granted for a limited period of 20 years (CIPC).

The Patents Act 1978 states what can be patented in South Africa:

1. A patent may, subject to the provisions of this section, be granted for any new invention which involves an inventive step and which is capable of being used or applied in trade and industry or agriculture.
2. Or anything which consists of:
  - i) a discovery;
  - ii) a scientific theory;
  - iii) a mathematical method;
  - iv) a literary, dramatic, musical or artistic or any other aesthetic creation;

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<sup>4</sup>Copyright Act 57 of 1978, commencement date 1 January 1979

- v) a scheme, rule or method for performing a mental act, playing a game or doing business;
- vi) a program for a computer; or
- vii) The presentation of information shall not be an invention for the purpose of this Act.

In general, the patents are very well protected under the South African patents protection mechanism.

In China, patent protection has a well-developed separate system with other intellectual protection bodies. The Patent Protection Association of China (PPAC) was founded in Beijing on October 9, 2003. The main task of PPAC is to safeguard the legal rights and interests of members and to introduce the members to enhancing intellectual property protection both in market competitiveness and in respecting other's rights. PPAC provides and exchanges information with the government and also makes recommendations to related government institutions. It participates in international activities on behalf of the members and aids members to solve problems on intellectual property. Other functions of the PPAC include patent consultation and feasibility studies, organising of training courses and international exchange programmes, and other related services (Patent Protection Association of China).

The Patent Law of the People's Republic of China was adopted on March 12, 1984, with effect from April 1, 1985. On December 19, 1984, the Chinese government submitted its instrument of accession to the Paris Convention for the Protection of Industrial Property to the World Intellectual Property Organisation and became a member state on March 19, 1985 (The Central People's Government of PRC, 2005). An invention patent in China protects "any new technical solution relating to a product, a process or improvement" (The Central People's Government of PRC, 1984) for a period of 20 years from the date of filing the patent application, as in other countries like the U.S.

However, Greguras and Banait (2004) argued that injunctive relief for a contractual breach (as opposed to infringement of statutory patent protection) is not certain in China and

reported that in general, selecting a trusted partner in China with the right IP practices and security infrastructure is a practical means of protecting IP (Greguras & Banait, 2004).

## Trademark

A South African registered trade mark is protected and defended under the Trade mark Act, 1993<sup>5</sup>. A registered trade mark in South Africa will be protected forever, but needs to be renewed every ten years upon payment of the prescribed renewal fee.

There are not many researches to describe the status quo of South African trade mark protection. However, the CIPC has a high responsibility to protect the good competitive environment in the South African market.

Generally, a trade mark can be registered for any goods which are going to be sold in South Africa. While common law rights are acquired through the use of a trade mark, the advantages of registration are substantial. Adams & Adams Company summarised that:

- an easy remedy (an action for infringement) is afforded whereby third parties may be restrained from using the same or closely similar marks for further information regarding infringement proceedings;
- it acts as a deterrent to potential infringers;
- the trade mark owner, by being in a position to offer the statutory protection of a registration, is more likely to attract licensees;
- it allows a trade mark owner or licensee to use the legend Registered Trade Mark or a suitable abbreviation thereof in conjunction with the trade mark; and
- it affords a prima facie (but not, it must be stressed, an absolute) right to use the trade mark concerned. (Adams & Adams, 2011)

A registered trade mark may, therefore, be offered as security or be attached in execution to find or confirm jurisdiction in the High Court in South Africa.

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<sup>5</sup> Trade mark Act 194 of 1993, commencement date 1 May 1995

The Trade mark Law of the People's Republic of China was first adopted in 1982. The Trade mark Law was revised in 1993, 2001 and in 2002 new Implementing Regulations were issued, in part, to bring China's trade mark legislation into compliance with the WTO Agreement on TRIPS. However, there were no stipulations on how the protection of trade-marks was to be enforced (Yang, 2003).

Companies who register a trade mark in China should also register Chinese language translations and appropriate Internet domains. The biggest challenge to foreign companies is the flexibility of the language. A slight change of a single Chinese character can completely alter pronunciation and meaning even though the character looks very similar. This adds further complications to legal definition should a trade mark be involved in a vicious competition.

Furthermore, there have been special provisions for the protection of "well-known" marks since 1996 in China. This special provision protects not only well-known Chinese marks, but also the internationally well-known marks. However, many companies continue to complain that their marks are not treated in the same manner as Chinese marks. Overall, for subjective and objective reasons, the reality is that there have been many arguments against Chinese trade mark protection, although they have not been as serious as in other sectors of IP protection. Consequently, Chinese trade mark protection is not strict and productive enough to provide a healthy competitive environment for enterprises.

### **Intellectual Property Protection**

The innovative effects of patent protection are difficult to measure, as there is no counterfactual for empirical testing – there are no industrialised countries in which patent protection does not exist at all. In addition, comparisons with developing countries with limited patent protection, but dissimilar industrial structures, would suffer from statistical weaknesses.

To study the implementation of IPR in South Africa, Teljeur (2002) gave many conclusions which can be referenced as judgement of the reality at present. The fact that implementation of the Patent Act consists of mere registration of patents, providing an

incentive for businesses in particular, is a matter of debate. Some practitioners argue that mainly large corporations file superfluous or excessively broad patents aimed at colonising large technology areas; other practitioners view small businesses or private individuals as the beneficiaries of strategic patenting. In any case, superfluous or strategic patenting is not beneficial in economic social welfare terms. (Teljeur, 2002)

It would thus appear that South African intellectual property laws are the 'best practice' and able to accommodate specific developing country concerns. However, despite these advanced provisions, some patent and design law practitioners claim that there are areas requiring reform. (Teljeur, 2002)

In China, 79% of computer users use pirate software ranking 27th in the world in 2009, compared to 20% for the U.S. and South Africa's 35%, which is an excessive figure. China had the most Internet users, a total of 240 million users at the end of 2009. It could be said that the loss for the software industry, not only for the U.S. but also for local Chinese software producers, is immeasurable.

The same phenomenon happens not only in the software sector, but also in car manufacture, the military industry, construction material and other high technology.

According to China's Supreme Court, more than 41,000 copyright infringement cases were filed in 2010, significantly more than the 30,000 cases filed just a year before. This lack of consistency does nothing to further confidence in China's ability or willingness to protect intellectual property (Papageorgiou, 2011).

## Summary

There are not many publications to evaluate how protection is working in South African society. Limited existing documents cannot really prove that IP protection is excellent, but reality shows that the existing policies and laws are driving the protection to provide a fair and healthy competitive environment for firms.

The protection of IP is a fatal weakness in the Chinese innovation system. The failure to protect intellectual property rights in the Chinese market leads to massive theft and piracy is constantly in the background.

Aspects	South Africa	China	Note
IP Policies	Moderate	Moderate	South Africa has regulated the Copyright Act since 1978. Since The Patent Law was launched in 1985 intellectual property rights have developed vibrantly in China.
Copyright	Excellent	Very Bad	Copyright Protection aims to offer proof of the existence of a specific file, script, design, literary, musical or literary work at a specific time and date. Chinese companies and underground organisations pirate goods at an alarming rate described by Microsoft's CEO as "sky high."
Patents for Invention	Good	Poor	South African criteria for originality of an invention are similar to those of most of the First World, such as Europe, USA and Australia. Selecting a trusted partner in China with the right IP practices and a secure infrastructure is a practical means of protecting IP
Trade mark	Excellent	Poor	While common law rights are acquired through use of a trade mark, the advantages of registration are substantial in South Africa. Chinese trade mark is not strict and productive enough to provide a healthy competitive environment for enterprises.
IP Protection	Good	Very Bad	It would thus appear that South African intellectual property laws are 'best practice' and able

Aspects	South Africa	China	Note
			to accommodate specific developing country concerns. In China 79% computer users use pirate software ranking China 27th the world in 2009 and South Africa only 35% .
<b>Overall</b>	<b>Good</b>	<b>Very Bad</b>	
<b>Intellectual Property Right Protection</b>	<b>Strength &amp; Opportunity</b>	<b>Weakness</b>	

Table 5.13 Summary of SWOT Analysis of IP Protection

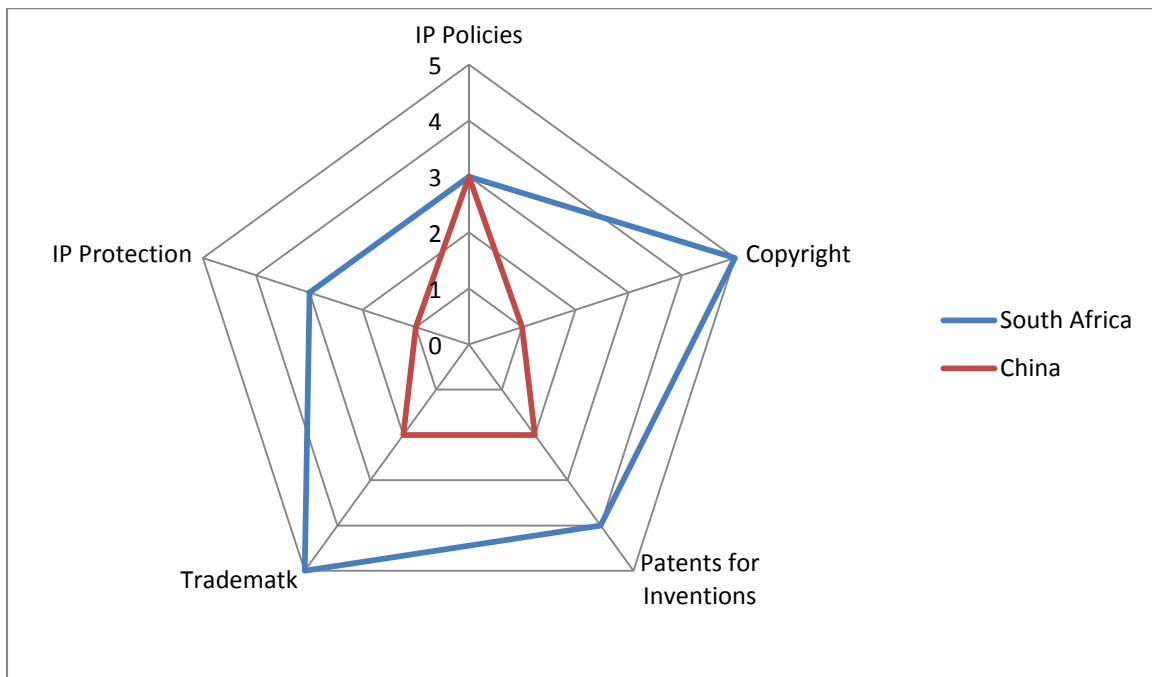


Figure 5.12 Radar Diagram of IP Protection

### 5.2.9 Technology Transfer

Technology transfer or knowledge transfer sometimes, is a key procedure in an entire innovation process. Any single brilliant innovation idea, without successful commercialisation, means nothing to the entire National Innovation System.



## Technology Transfer Policy

In South Africa, the technology transfer policy (Bay Dole Act) is imperative that a discussion and understanding of the origins of such policy is undertaken. Fundamental elements to be considered are taken into account in formulating such policies, these include and are not limited to a property rights frame work, public/private financing, institutional agreements etc. (Sooryamoorthy R. , 2011).

South Africa has made government support for research and innovation a key part of the national economic-development strategy. In August 2002, South Africa's government approved a new national R&D strategy, and discussions continue for implementing the new strategy, including national funding for technology transfer. Funding for commercialisation activities and patents is critical, but a major capacity-building and development effort is under way. This effort will build upon capabilities that exist in a few universities and public research councils (Young, T. 2007).

As part of its national strategy, the South African government established its Innovation Fund to promote technology innovation, which has increased networking and cross-sector collaboration. The fund has invested South African Rand 650 million in more than 100 projects. Many of these have produced patents and in some cases spinout companies. Most recently, the government established the Innovation Fund Commercialisation Office (IFCO), a centralised office to provide one-stop support for protecting and commercialising intellectual property rights for all of the nation's public research organisations. IFCO complements existing technology transfer offices in South African public research organisations (Young, 2006).

In October 2005, the Communist Party Central Committee and China's Government stipulated the Guiding Vision for the 11<sup>th</sup> National Economic and Social Development Programme (2006-2010). It emphasises the importance of adjustment of a development strategy which should be economising material inputs, upgrading economic structure and innovative capability, be friendly to environmental protection, has a balance between urban and rural development and between the development in eastern, middle and western

regions, and maintaining job creation and social equality (CCCPC 2005). The key for realising the new strategy is “indigenous innovation” and continuous reforms to build harmonious development. One can see that the new strategic vision accommodates several of the problems discussed above. (Gu & Lundvall, China’s Innovation System and the Move Toward Harmonious Growth and Indigenous Innovation, 2008)

Chinese government prefers to encourage enterprise indigenous innovation. On the other hand, the Chinese government allows and encourages local companies to collaborate with universities or foreign technology companies, but China has no policies from government side or investment in such fields at present. Universities, enterprises, research institutes and agents are playing their role in the system freely.

### **Technology Commercialisation**

South Africa is seeking to build strong links between its emerging technology transfer system and S&T system. The Southern African Research & Innovation Management Association (SARIMA) was formed in 2002 to assume the lead role in national efforts to build capability in research and innovation. The SARIMA is established to build a new culture of innovation inside the research community, ensuring that all benefits of research are understood and exploited in South Africa.

Chinese products always give the impression of sleazy stuff, but actually the high- and mid-technology products are getting a bigger and bigger proportion in the country’s trade. High-tech imports share in total imports increased from 16.3% in 1995 to 34% in 2008. The export in high-tech products has increased rapidly, from 20 US billion Dollars in 1995 to around 415.6 US billion Dollars in 2008 and shares 29.1% of total exports.

A research study shows that before 1998, only Tsinghua University and Peking University in Beijing operated technology transfer offices (TTO) in China. Today, most public research organisations in China have a TTO. These were originally supported by the Chinese government, but as China moves from a state-planned economy to one that is more market based, this TTO funding model is changing. Most of the TTOs today operate as associated private companies, solely owned by the corresponding university and initially supported

with university funds. As private companies, these TTOs are very active in business-development services, such as setting up incubators, assisting small- and medium-sized enterprises to prepare business plans, helping develop spinout company requirements, investing in new spinout companies with university-based venture funds, etc. (Young, 2006).

### **University to Industry Partnership**

Universities and companies are not natural partners and their missions and cultures can work to inhibit or prevent smooth collaborations and hence a metaphor for difficult issues is experienced.

The Technology Stations Programme of South Africa is designed to strengthen and accelerate the interactions between Universities and SMMEs. The Technology Stations funded under this programme will play a major role in identifying the specific needs of SMME's and will provide the adequate technology solutions based on the Universities' full potential to improve the competitiveness of their SMME clientele in selected sectors.

Literature cites a number of challenges which differ from lack of significant research activities or outputs to research objectives in comparison with the global norms. For instance, the international community's objective for pursuing technology transfer is to improve public good, implying to create the greatest possible economic and social benefits from the research whether or not benefits are accrued to university (Pouris, 2006).

China's technology bridging system has progressed rapidly recently, but still lags that of developed countries and is unable to satisfy the needs of the other actors in its NIS. Specifically, China's technology bridging system has followed the American model and emphasises indirect support as the basis for the construction of an innovation-related environment. However, current national conditions make it very difficult for China to achieve a transparent financial and legislative environment like that of the US. On the other hand, compared to Taiwan or Japan, China lacks the function of direct support for S&T activities within its technology bridging system (Chang & Shih, 2004).

## Summary

During the studies of the Chinese innovation system, there is always a question to be asked: Why is the S&T level high, but the low-cost or low-tech products are manufactured and exported so much? China may need to pay more attention to technology transfer. At the same time, the government is the key to correct the problem that emphasises S&T capability, but with a lack of attention on the commercialisation.

Aspects	South Africa	China	Note
Technology Transfer Policy	Excellent	Poor	South Africa has made government support for research and innovation a key part of the national economic-development strategy. Chinese government prefers to encourage enterprise indigenous innovation. On the other hand, Chinese government allows and encourages local companies collaborating with universities or foreign technology companies, but China lacks policies from government side or investment to such fields at present.
Technology Commercialisation	Moderate	Poor	The SARIMA was formed in 2002 in SA to assume the lead role in national efforts to build capability in research and innovation. High-tech imports share in total imports increase from 16.3% in 1995 to 34% in 2008. The export in high-tech products around 415.6 US billion Dollars in 2008, shares 29.1 of total exports. For China, reference the TT Policies aspect.
University to Industry	Excellent	Good	The Technology Stations Programme of South Africa is

Aspects	South Africa	China	Note
Partnership			designed to strengthen and accelerate the interactions between Universities and SMMEs. China's technology bridging system has progressed rapidly recently, but still lags that of developed countries and is unable to satisfy the needs of the other actors in its NIS.
Overall	Good	Moderate	
Technology Transfer	Strength	Weakness & Opportunity	

Table 5.14 Summary of SWOT Analysis of Technology Transfer

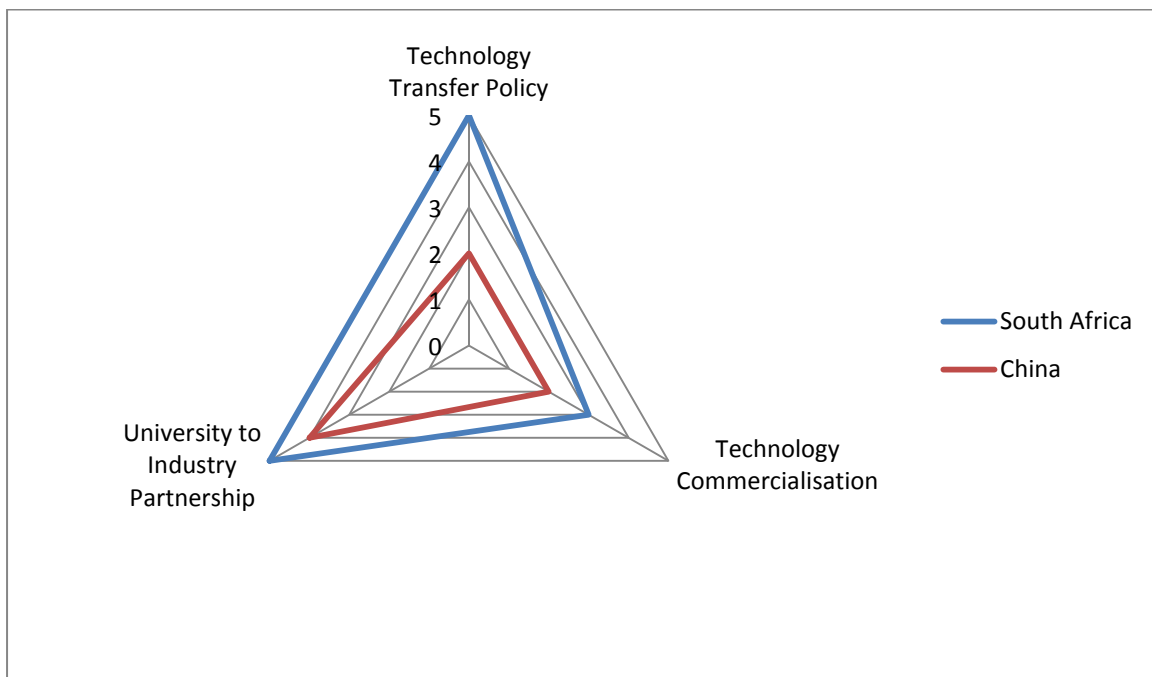


Figure 5.13 Radar Diagram of Technology Transfer

### 5.2.10 Government Research Institutes (GRI)

As introduced in Chapter 4, The National Research Foundation (NRF) manages South Africa's national research facilities. It promotes and supports basic and applied research. The NRF oversees the following national research facilities:

- South African Astronomical Observatory
- Hartbeesthoek Radio Astronomy Observatory
- Hermanus Magnetic Observatory
- South African Institute for Aquatic Biodiversity
- South African Environmental Observation Network
- National Zoological Gardens
- iThemba Laboratory for Accelerator-based Sciences (South Africa Online)

In China's national innovation system, government research institutes are still playing a key role in supporting basic and strategic research, and research related to the provision of public goods. The research activities of government research institutes in China are highly concentrated in the field of natural sciences and high-tech related disciplines. In 2005, expenditure on natural sciences and engineering accounted for 94.7% of gross R&D project expenditure of government research institutes.

The size and complexity of the S&T-system made reform crucial for the success of economic growth. By 1980 there were 4,690 research institutes affiliated to administration bodies higher than the "county" level, i.e. to central, provincial, and regional/city governments, with some additional 3000 institutes at the county level, the lowest level of the nation's administration hierarchy with an independent budget (White Paper). 323,000 scientists and engineers worked in these institutes (Gu & Lundvall, China's Innovation System and the Move Toward Harmonious Growth and Indigenous Innovation, 2008). China has more than 500 main government research institutes almost covering all science and technology fields.

## Summary

National research institutes show enormous differences between South Africa and China. The institutes owned by the South African government are leaders of each area. They have researching functions, but the more important role is providing leadership. Although it doesn't take place in many S&T missions, national research institutes have a scientific function distinction and active leadership role in the NIS of South Africa.

On the other hand, Chinese national research institutes undertake most of the S&T development missions. They are led directly by the central government. The over 4600 research institutes are powerful tools of Chinese central government for the country's innovation development.

Aspects	South Africa	China	Note
<b>Overall</b>	<b>Moderate</b>	<b>Excellent</b>	The National Research Foundation (NRF) manages 7 South African national research facilities. There were 4,690 research institutes affiliated to administration bodies higher than the "county" level
<b>Government Research Institutes</b>	<b>Strength</b>	<b>Strength</b>	

Table 5.15 Summary of SWOT Analysis of Government Research Institutes

Star diagram is not applicable for this part.

### 5.2.11 Small and Medium Enterprises

The SMEs play important roles in South Africa. The statistics show that the larger the GDP of a province, the higher the number of SMEs in South Africa. This fact supports the notion that Small and Medium Enterprises require collective efficiency, external economy and the benefit of economic agglomeration.

### Policy Environment

South Africa has a world-class, progressive legal framework. Legislation pertaining to commerce, labour and maritime issues is particularly well developed, while laws relating to competition policy, copyright, patents, trade-marks and disputes conform to international norms and conventions.

The South African National Small Business Act (National Small Business Act, 1996) categorised business as five types: survivalist enterprises, micro enterprises, very small enterprises, small enterprises and medium enterprises. Due to the comparison between the

countries, the SMME, defined by The National Small Business Act, will be classified as SME as for the other three countries. Although the definition is slightly different, SMME has the same function in South Africa's National Innovation System as with the other SMEs.

Most provinces refer to SMMEs in major economic development policy documents such as provincial Growth and Development Summit declarations and Growth and Development Policies, youth development policies, etc. Moreover, there are many websites and companies which help the SMEs by supporting the business plans, financial solutions or other toolkits.

Since the advent of democracy, the Government has increasingly acknowledged the value of co-operatives as enterprises and organisations inspired by solidarity to ensure greater black participation in the mainstream economy, especially participation by persons in rural areas, women, people with disabilities, and the youth. This resulted in the publishing of the Co-operative Development Policy in 2004, followed by the Co-operatives Act (Government Gazette, 2005) in 2005. At present the Integrated Strategy on the Promotion of Cooperatives and Collective Entrepreneurship is being formulated. (Department of Trade and Industry, 2008)

At the moment, the Chinese government's financial support to SMEs includes mainly special funds for investment and investment in industrial policy. Banks that grant loans to SMEs include the China Minsheng Bank, city commercial banks, urban credit cooperatives and other financial institutions. The "SME Promotion Law" was formally implemented in 2003, but compared with developed countries; China still has no uniform primary and secondary Basic Enterprise Law, which makes it difficult for SMEs to develop a special status and individual characteristics of the corresponding legal norms. This means that it is not possible for SMEs to provide equal competition regarding technological innovation and the legal environment lacks effective property rights incentives.

The purpose is the creation of a business environment that supports the globalised fast follower innovation mode as an important means of facilitating the continued evolution of



existing SMEs in China, which has hitherto comprised of small firms focused on low-skill, final-goods assembly for the domestic market.

### **SME Development**

South Africa ranked 35<sup>th</sup> out of 178 countries in the World Bank and International Finance Corporation's Doing Business 2008 report, an annual survey that measures the time, cost and hassle for businesses to comply with legal and administrative requirements. South Africa was ranked above developed countries, such as Portugal (37) and Spain (38), as well as major developing economies such as China (83), Russia (106), India (120) and Brazil (122). (South Africa: open for business)

The case for employment creation and wealth distribution through small business is based on sound economic sense. Small businesses have been identified as labour-intensive, have the need for little capital and make use of the local resources available. By channelling these resources to the small business sector, particularly in a growing and developing economy like South Africa's, employment opportunities can be maximized and people are given the opportunity to contribute to the development of the economy. A research study identified that the small business sector contributes approximately 32.7% to South Africa's gross domestic product (GDP). In fact, in 1998, the small business sector accounted for about 41% of the country's gross domestic product. (Johnson, 2005)

The economic transition of China has led to an increase in the importance of small and medium-sized enterprises (SMEs), which currently represent 99% of all Chinese enterprises. Around 75% of total jobs in urban areas are held at SMEs, which absorbed a big part of the labour force formally employed by state-owned enterprises as well as most of the 200 million rural migrants moving into urban areas since the beginning of the reforms. Nonetheless, the importance of SMEs for the Chinese economy and society was only recognised some years ago. Despite their growing significance, SMEs still lack appropriate promotion structures and instruments.

Although SMEs have the majority in quantity, big enterprises are still the main power of the Chinese economy. According to the statistics from the share market, SMEs hold

approximately 20% of the total market value and big companies and nation-held companies take the rest. This illustrates that the contribution to the economy from SMEs is still limited; it also means that SMEs, relatively, do not play the main role in the Chinese National Innovation System.

Problems facing Chinese SMEs are many and varied. Chinese SMEs are constrained from achieving economies of scale in the purchase of inputs such as equipment, raw materials, finance, and consulting services; are often unable to access global markets; and are also limited in their performance in increasingly open, competitive domestic markets. Because of their size, it is difficult for Chinese SMEs to access functions such as training, market intelligence, logistics and technology. As such, they are unable to take advantage of market opportunities that require large volumes, homogeneous standards and regular supply. Furthermore, firms compete more and more not only on the basis of prices, but on the basis of their abilities to innovate, or upgrade. Improvements in product, process, technology, and organisational functions such as design, logistics, and marketing have become the critical success factors in firm competitiveness in a globalising economy. Chinese SMEs are thus under pressure to innovate and to upgrade their operations in order to participate in international markets. However, they often lack the resources to do so. (Kanamori, Lim, & Yang, 2007)

One challenge facing the SME sector in China is the problem of the “missing middle”. While this may well be an indigenous market outcome, there is a possibility that distortions have arisen as a result of China's economic history of central planning (Kanamori, Lim, & Yang, 2007).

Although most firms in a cluster or network may be small, we define an “organised cluster” as a cluster that exhibits active cooperation and maintains directed linkages among participating firms, usually with the involvement of government policymakers at either the infrastructure or coordination level. This occurs when SMEs in a cluster or network evolve together, after the realisation that, by working together as a group, they obtain advantages that allow them to compete in the global economy, which they may not have if they act as individual, isolated small enterprises. As the cluster matures, the focus shifts toward

establishing new relationships with other network clusters, and consolidating relationships with the functional agents. (Kanamori, Lim, & Yang, 2007)

### Ease of Doing Business

To evaluate this aspect, a rank from The World Bank Group will be referenced. This rank analysed the ease of doing business, from 1 – 183.

Countries	Ease of Doing Business Rank	Starting a Business	Registering Property	Protecting Investors	Paying Taxes	Trading Across Borders	Enforcing Contracts	Closing a Business
South Africa	34	75	91	10	24	149	85	74
China	79	151	38	93	114	50	15	68
Finland	13	32	55	59	65	6	11	6
USA	5	9	12	5	62	20	8	14

Source: (The World Bank Group, 2010)

Table 5.16 Ease of Doing Business Rank

A high ranking on the ease of doing business index means the regulatory environment is more conducive to the starting and operation of a local firm. This index averages the country's percentile rankings on 9 topics, made up of a variety of indicators, giving equal weight to each topic. The rankings for all economies are benchmarked up to June 2010.

### Summary

The analysis of SME development showed that South Africa has better developed strategies and policies than China to encourage and help SMEs. Chinese economy, in many fields, over depends on the nation owned companies. The fact results in that the SMEs are surviving in the cracks.

<b>Aspect</b>	<b>South Africa</b>	<b>China</b>	<b>Note</b>
Policies Environment	Excellent	Poor	South Africa has many policies to support SME growth. Besides the country wide policies, provinces also have their own policies to support SMEs. Chinese government financial support to SMEs by providing mainly special funds for investment and investment in industrial policy, but to date there is only one bank which mainly supports SMEs.
SME Development	Good	Moderate	South Africa ranked 35 out of 178 countries in the World Bank and International Finance Corporation's Doing Business 2008 report and China ranked 83.
Ease of Doing Business	Good	Moderate	South Africa ranked at 34 and China at 79 in 183 countries.
<b>Average Credit</b>	<b>Good</b>	<b>Moderate</b>	
<b>Small and Medium Enterprises</b>	<b>Strength</b>	<b>Weakness &amp; Opportunity</b>	

Table 5.17 Summary of SWOT Analysis of SMEs

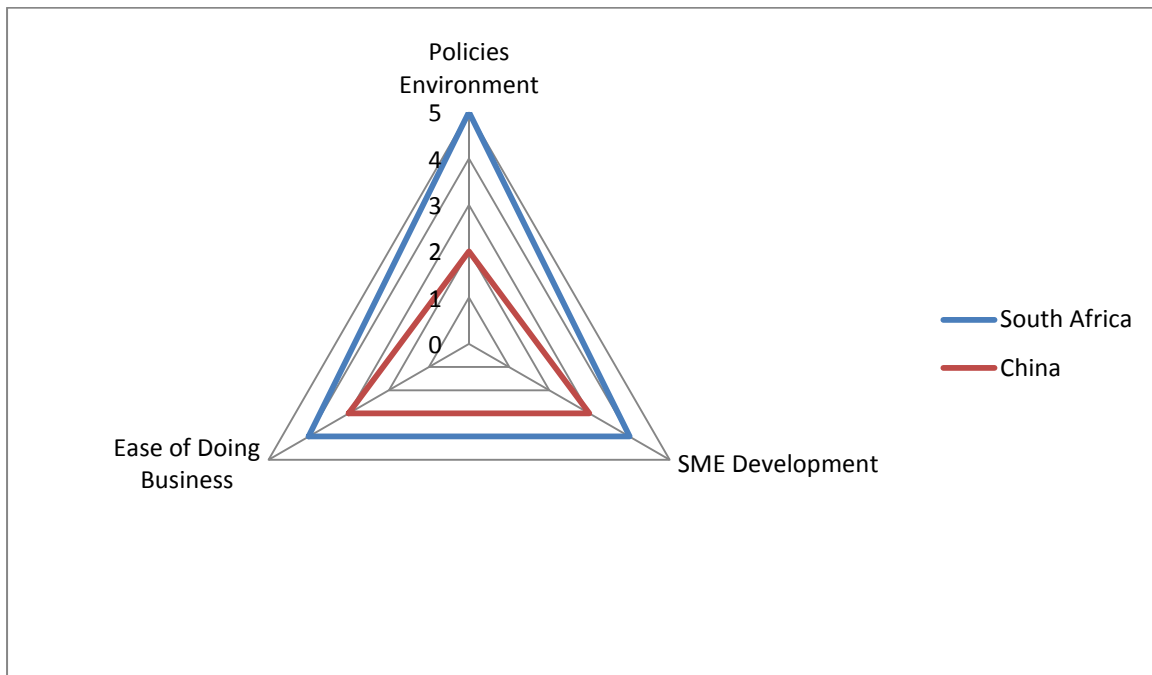


Figure 5.14 Radar Diagram of SMEs

### 5.2.12 International Cooperation

International cooperation in innovation is getting more and more important in these times which require knowledge and information. All sectors of the industry are looking for globalisation opportunities.

#### Business Globalisation

Since signing the Global Agreement on Tariffs and Trade in 1994, South Africa has become a player in the global trading system, and a series of trade reforms, including a tariff reduction and rationalisation programme, have been implemented.

In recent years, South Africa has also developed strong relations with markets in the rest of Africa, Asia and Latin America. The India-Brazil-South Africa Alliance (IBSA), formed in 2003, aims to increase trade between the three countries from the current level of around US\$6 billion to \$10 billion within the next few years. And South Africa has become a key trade and investment partner to China, which over the past decade has become a major player on the African continent. (South Africa: open for business)

Moreover, South Africa has the resident marketing skills and distribution channels imperative for commercial ventures into the whole of Sub-Saharan Africa. The country plays a significant role in supplying energy, relief aid, transport, communication and outward investment on the continent.

China is the largest exporting country and second largest importer, and is not only well involved in the international market, but is also playing a very important role in the world economic growth.

A report from RAND mentioned that all of China's economic successes are associated with liberalisation and globalisation, and each aspect of globalisation has brought China further successes. Never in world history have so many workers improved their standards of living so rapidly. Thus, popular support for globalisation is greater than in Japan, where post-war recovery occurred in a highly managed economy, or with the former Soviet Union, where shock therapy traumatised society (Overholt, 2005). Consequently, China has effectively become an ally of the U.S. and the Southeast Asian promotion of freer trade and investment than is acceptable for Japan, India and Brazil.

The report also pointed out that China's success is one of the most important developments of modern history, but projecting from current growth to Chinese global dominance or threats to our way of life is just unacceptable. Unlike the old Soviet Union, reformist China does not seek to alter any other country's way of life. Its economy faces world history's most severe combination of banking, urbanisation and employment challenges and by 2020 a demographic squeeze that will have few workers supporting many dependents. The best outcome for us would be a China that is eventually like Japan, prosperous, winning in some sectors, losing in others. Signs that China is making rapid progress in that direction should be welcomed, not feared. (Overholt, 2005)

China is organising inspection teams to find the best solutions in the world, foreign technology and corporation management skills, as well as other routines, such as international accounting codes, security laws in England and Hong Kong and the military product system in France that have been used. The framework of the central bank has been

established according to the model of the American Federal Reserve Bank. Security investment in foreign countries uses the system from Taiwan. The strategy of economic development refers to the strategy used in Korea, Singapore, and Taiwan. There are still some references from the other regions. China's most important changes are the use of western laws to make competition an important element in the marketing economy and to use the English language as a second language in education.

South Africa and China are now both members of BRICS. South Africa and China should cooperate to a very high degree with each other as two different role players in world economy, as well as two economic growth leaders in each respective region.

### **R&D collaboration**

South Africa participates in wide international cooperation with many countries in R&D. Europe is one of South Africa's most strategic partnerships in international science and technology. South Africa and Europe have built a strong science and technology connection through the European-South African Science and Technology Advancement Programme.

At the multi-lateral level, South Africa has a research agreement with the European Union and observer status at the OECD Committee for Science and Technology Policy. The EU agreement allows them to participate in the European research and development framework. This creates unique opportunities to link South Africa (and SADC) with the networks of research in Europe. As South Africa supports stronger participation in these frameworks, with a focus on groups such as women and researchers from previously disadvantaged groups, the likelihood of South African researchers remaining in South Africa is strengthened since researchers will not feel the pressure of being "excluded" from global research networks. It is critical; therefore, that South Africa strategically supports their global science initiatives far more actively than they have done in the past. Their relationship with the OECD has been enormously productive from a policy and strategy perspective and a number of the analyses that underpin the current National R&D Strategy development can be attributed to insights gained through this key relationship.

In terms of collaboration, publications can be classified into collaborated and non-collaborated papers. Collaboration happens at the domestic level when authors are from within the country or at the international level when at least one author joins from overseas. Domestic collaboration is further bifurcated into internal-institutional (authors belonging to the same department or institution within South Africa) and external-institutional (authors from different institutions in South Africa). Out of the total of 2,036 papers produced during the period of analysis, 1,492 (73%) were collaborated papers. The proportion of collaborated papers was 56% in 1975 which had increased to 81% by 2005. The papers produced in internal-institutional collaboration declined from 75% in 1975 to 47% in 2005. On the other hand, external-institutional collaboration grew from 10% in 1975 to 19% in 2005 (Sooryamoorthy R. , 2011).

South African criteria for the originality of an invention are analogous to those of most countries of the First World, e.g. Europe, the USA, Japan and Australia. However, South Africa's inventive step requirements differ from some of these countries. Consequently, the International Search Report and the International Preliminary Examination Report should be consulted when examining a South African application. This will indicate whether the PCT International Specification as filed and published should be amended when filing a South African application. Importantly, such a step lessens the possibility that a South African patent, which may be granted on the application, will be deemed invalid on the grounds of lack of inventive steps.

China witnessed a marginal decrease in the share of international collaborative papers from 40.74% during the period of 1999-03 to 39.36% during the period of 2004-08. The United States was the largest collaborating partner during 1999-08, by contributing a 45.38% share in China's total international collaborative papers in Neurosciences during 1999-08, followed by Japan (13.09% share), Taiwan, Canada, Germany, Sweden, and Australia, France, UK, Netherlands and Singapore. (Bala & Gupta, 2010)

China has cooperated through programmes in science and technology with 152 countries and regions, signed inter-governmental sci-tech cooperation agreements with 96 countries and joined more than 1,000 international sci-tech cooperation organisations. Non-



governmental international cooperation and exchanges have also been increasing. (Science and technology in the People's Republic of China)

In 2008 South Africa exported most of its high technology to Germany, followed by France, Nigeria and Zambia. South Africa imported most high technology products from China, followed by the USA, Germany and Sweden.

### Summary

Most countries are dependent on each other for their macro-economic health. Seriously unbalanced business trading would have a crippling effect on the economy.

South Africa is too dependent on exports, particularly of natural resources, although it has to be fully understood that it is the development model of the country. South Africa has been very well involved in global development and contributes to the world economy. Being involved in BRICS is very strong evidence. China opened her doors in 1979 and became a WTO member in 1995 and is now called the “World Factory”. China differs from South Africa in that China is a surplus exporting country, which means that China is also very dependent on the world economy. Being the most important developing countries, both countries are driving the world development dynamic not only in the economy, but also in the science and technology spheres.

Aspect	South Africa	China	Note
Business Globalisation	Good	Excellent	South Africa has developed strong relations with markets in the rest of Africa, Asia and Latin America. China is the largest exporting country and second largest importer and is not only well involved in the international market, but also plays a very important role in the world economic growth.
R&D collaboration	Good	Good	South African criteria for originality of an invention are analogous to those of most of

Aspect	South Africa	China	Note
			the First World. China has cooperated through programmes in science and technology with 152 countries and regions.
<b>Overall</b>	<b>Good</b>	<b>Good</b>	
<b>International Cooperation</b>	<b>Strength and Opportunity</b>	<b>Strength and Opportunity</b>	

Table 5.18 Summary of SWOT Analysis of International Cooperation

A star diagram is not applicable for this section.

### 5.2.13 Other Factors

Besides the aspects above, there are other factors influencing the NIS system of each country. Those factors are not always considered as criteria. While researchers study NIS, specific problems would influence the NIS for each country.

### Crime

Many South Africans remain poor and unemployment is high - a factor blamed for a wave of violent attacks against migrant workers from other African countries in 2008. South Africa is suffering a big problem with crime. According to statistics from the United Nations Office on Drugs and Crime, the Centre for International Crime Prevention, South Africa ranks number 1 in murders with firearms, with 31,918 cases in 2002 (United Nations Office on Drugs and Crime, Centre for International Crime Prevention, 2002) . This number is 10,000 more than Colombia which ranks second. It definitely poses a massive threat to the nation's stability. Worries about security have shaken the confidence of investors which has been strongly reflected on the NIS development of the country. Even if there is a decline in the crime rate in the next few years, it is optimistically thought that the influences of crime will last for years.

## **Gap between Rich and Poor**

Poverty is a potential threat to the stability of South African society. The gap between rich and poor has reached the highest level. Although the government is trying to increase job opportunities, strikes obviously happen more frequently than ever. The reason for this is complex and complicated problems brought about by this phenomenon influence the social development, which includes the NIS of South Africa. On the other hand, a poor population stores a high potential for market growth and can also provide cheaper labour for the country. The Labour Act should try to protect workers' rights by considering economic growth and employment, especially, when unemployment is over 25% in South Africa, overprotection of workers is poisoning the economy and society.

## **Corruption**

Economic crime and corruption are increasing fast in South Africa since the country has been involved with the BEE policy (Black Economic Empowerment). The PricewaterhouseCoopers's fourth biennial Global Economic Crime Survey reported a 110% increase in fraud reports from South African firms in 2005. 83% of South African companies reported being affected by white collar crime in 2005, and 72% of South African companies reported being affected in 2007. This phenomenon could cause unfair competition, protects illegal business and generates cut-throat competition monopoly and protectionism. Corruption also generates the intangible cost of innovation becoming uncontrollable for business through illicit payments. The corruption in South Africa may influence or even threaten the stability of the government.

## **Public Health**

Public health is also influencing the NIS in South Africa. The mortality rate, as stated by the WHO, is subject to age-specific mortality rates, as for example the under-five mortality rate, which refers to the probability per 1,000 new-born babies who die before reaching the age of five. In 2009, the mortality rate in South Africa was 62 per cent which was extremely high for an upper middle income country, comparing to 19% in China, 8% in the U.S. and 3% in Finland. Public health plays a bad role in South Africa's NIS.

## **HIV/AIDS**

An estimated 5.6 million people were living with HIV and AIDS in South Africa in 2009, more than in any other country. It is believed that in 2009, an estimated 310,000 South Africans died of AIDS. Prevalence is 17.8 per cent among those aged 15-49, with some age groups being particularly affected. The impact of the AIDS epidemic is reflected in the dramatic change in South Africa's mortality rates. The overall number of annual deaths increased sharply from 1997, when 316,559 people died, to 2006 when 607,184 people died. This rise is not necessarily due solely to HIV and AIDS but it is young adults, the age group most affected by AIDS, who are particularly shouldering the burden of the increasing mortality rate. In 2006, 41 per cent of deaths were attributed to 25-49 year olds, up from 29 per cent in 1997. This is a strong indicator that AIDS is a major, if not the principal; factor in the overall rising number of deaths. (AVERTing, 2010)

## **Unemployment**

Unemployment directly caused poverty and increased the gap between rich and poor in South Africa. The unemployment rate among all 15- to 24-year-olds is 51 per cent, more than twice the national unemployment rate of 25 per cent.

South Africa's unemployment rate (in terms of both the official and the expanded rate) is very high and constitutes a key challenge for the country's development agenda. Of those who are employed, around 80% are in the formal sector, and around 80% are in occupations above the elementary level (meaning that to perform their jobs, these people depend on job-specific skills training) (September.P, 2010).

## **Population**

According to the analysis above, particularly in R&D expenditure and the Human Resource sectors, China has greater advantages in gross expenditure, FTE personnel and university enrolment. However, strength became weakness for the country after the aspects were calculated as per capita. Population is a huge problem to this fast growing country and the fact that China is facing problems which have never been experienced by any country before

further aggravates the problem. How to assign resources and capital equally, correctly and rationally is a crucial challenge to China.

### Ageing Population

Meanwhile, an ageing population is another problem which China faces. Since the Single-Child Policy was introduced in 1979 in an attempt to control China's booming population, a growing number of single young people are finding themselves faced with the daunting prospect of caring for parents and four grandparents - a phenomenon known as a 4-2-1 family. A halt or decrease in the population growth will result in China facing an intensive ageing population problem. Government has the responsibility to correct the population structure as soon as possible, or the burden of caring for a greying population could begin to have a major impact on the speed of China's development.

### Summary

More problems which are also critical to the NIS of South Africa and China were pointed out in this part beyond the criteria. The reason these factors were not classified in the criteria, is either the problem was not mentioned in any literature before or it is specific to the country.

The following table summarised the other aspects in South African and Chinese NIS.

Other Aspects	South Africa	China
Strengths		
Weaknesses	HIV/AIDS, Poverty	
Opportunities	Poor Population	
Threats	Crime, Corruption, Gap between rich and poor, Poverty and Public Health	Corruption, Population and Ageing Population

Table 5.19 Other Factors

## 5.3 Summary of SWOT Analysis

This part summarised the SWOT analysis result with above detailed analysis. The result of this analysis is given by using both a radar diagram and classic SWOT analysis table.

### 5.3.1 SWOT Analysis Output

In Chapter 5, there were 12 criteria that have been analysed by doing the SWOT analysis. The table below presents again the identified criteria for this research.

	Identified Criteria
1	Government Leadership
2	Strategy & Policies
3	R&D Expenditure
4	Human Resources
5	Higher Education
6	S&T Development
7	Paper Citations & Impact Factor
8	IP Right Protection
9	Technology Transfer
10	Government Research Institutes
11	Small and Medium Sized Organisations
12	International Cooperation
13	Other Factors

Table 5.20 Criteria after SWOT Analysis

The diagrams are presented below the summary table. A star diagram is not applicable to this field, which included less than two aspects. IP Right Protection, Government Research Institutes and International Cooperation are not presented in a star diagram.

As the result output for this SWOT analysis, a star diagram is used to observe the innovation system strengths between South Africa and China.

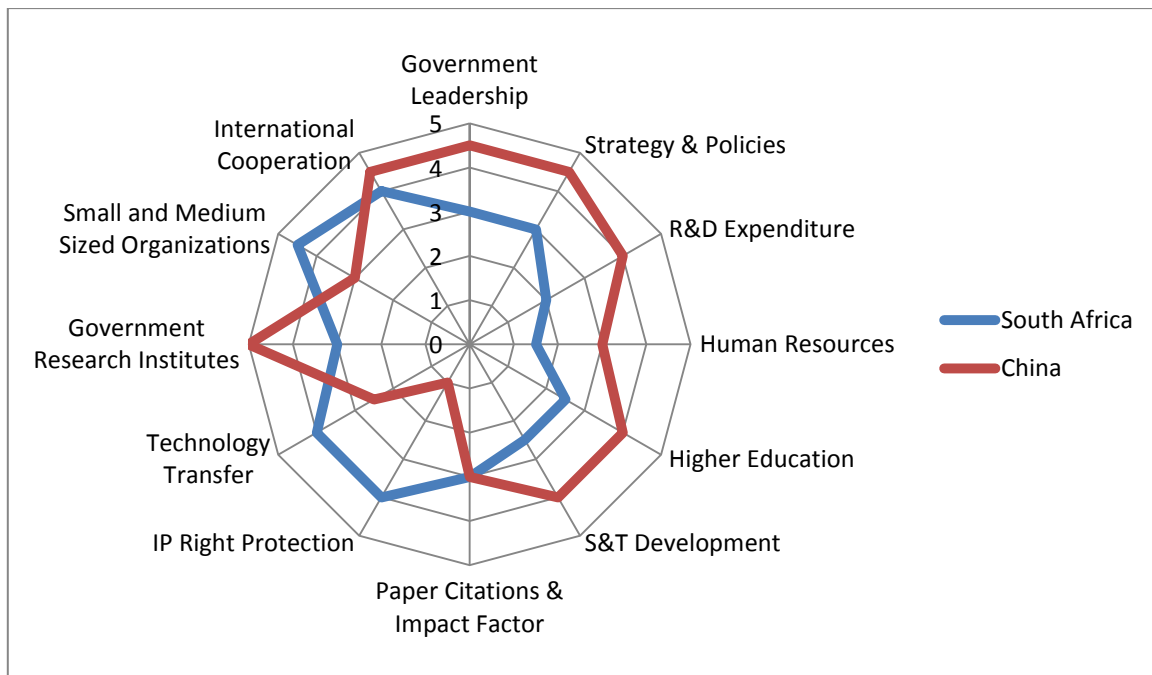


Figure 5.15 Radar Diagram of the SWOT Analysis

### 5.3.2 SWOT Analysis Summary

The following two pages give the typical SWOT analysis table for NIS of South Africa and China separately.

### SWOT Analysis on South African Innovation System

Strengths	Opportunities
<ul style="list-style-type: none"> <li>• Technology Transfer, because of good policies support and university/industry interaction.</li> <li>• Paper Citation and Impact Factor, see table 5.11.</li> <li>• Government Research Institutes, because well-developed system.</li> <li>• Small and Medium Enterprise, because the policies and strategies support.</li> <li>• Intellectual Property Right Protection, because good laws</li> <li>• International Co-operation, because actively participate in international cooperation.</li> </ul>	<ul style="list-style-type: none"> <li>• Intellectual Property Right Protection, because sharing experience with other countries.</li> <li>• International Co-operation, because involving globalisation.</li> <li>• Poor Population, because of huge market potential.</li> </ul>
Weaknesses	Threats
<ul style="list-style-type: none"> <li>• Government Leadership, because of fragment leadership and slow reaction.</li> <li>• R&amp;D Expenditure, see table 5.4 and figure 5.4</li> <li>• Human Resource, because low numbers of personnel.</li> <li>• Higher Education, because of numbers of universities and top-class universities.</li> <li>• Science and Technology Development, because sluggish development recently.</li> </ul>	<ul style="list-style-type: none"> <li>• Strategy &amp; Policies, because of the BEE and short-sight strategies.</li> <li>• Human Resource, because of brain-drain problem.</li> <li>• Higher Education, because ranks of universities are going down.</li> <li>• Brain-Drain, because of losing personnel.</li> <li>• Crime, because it brings social instability.</li> <li>• Corruption, same as above.</li> <li>• Gap between Rich and Poor, same as above.</li> <li>• HIV/AIDS, because of affecting sustainable development.</li> </ul>

Table 5.21 SWOT Analysis on South African Innovation System



## SWOT Analysis on Chinese Innovation System

Strengths	Opportunities
<ul style="list-style-type: none"> <li>• Government Leadership, because of good strategic positioning.</li> <li>• Strategy &amp; Policies, because of the political centralisation.</li> <li>• R&amp;D Expenditure, see table 5.4 and figure 5.4.</li> <li>• Human Resources, because of the immense number of personnel.</li> <li>• Higher Education, because of the number of universities and university students.</li> <li>• Science and Technology Development, because of the achievements in last 10 years.</li> <li>• Government Research Institutes, because of the numbers of GRIs and the role they play.</li> <li>• International Co-operation, because of good involvement in global economy.</li> </ul>	<ul style="list-style-type: none"> <li>• Higher Education, because of the higher education quality.</li> <li>• Technology Transfer, because of the capacity of university/industry interaction.</li> <li>• Small and Medium Enterprises, because of the increasing numbers of SMEs.</li> <li>• International Co-operation, because there is more technology cooperation.</li> </ul>
Weaknesses	Threats
<ul style="list-style-type: none"> <li>• Paper Citation and Impact Factor, see table 5.11.</li> <li>• Small and Medium Enterprises, because of lack of policy support.</li> <li>• Intellectual Property Right Protection, because of fragment protection.</li> <li>• Technology Transfer, because of bad interactions.</li> </ul>	<ul style="list-style-type: none"> <li>• Human Resources, because of brain-drain problem.</li> <li>• Political Factors, because of high political centralisation.</li> <li>• Human Rights, because it brings social instability.</li> <li>• Corruption, because it causes capital outflows.</li> <li>• Population, because it causes heavy social burden.</li> <li>• Ageing Population, because it brings increasingly heavy social burden.</li> </ul>

Table 5.22 SWOT Analysis on Chinese Innovation System

### **5.3.3 Conclusion and Recommendation**

According to the entire analysis process, the conclusion of South African and Chinese NIS will be given separately in this part. Some recommendations to those two countries are also mentioned while summarising the SWOT analysis.

#### **5.3.3.1 South Africa**

The study recognises the fact that the South African innovation system remains fragmented and that the country is becoming less competitive. Lack of highly-skilled human resources and high attrition rates are critical problems that limit the stability of economic development.

Reviews of the Innovation Policy from the OECD report: South Africa mentioned that the South African innovation system needs to strengthen the mechanisms for integration across, or changing the current organisational location of key interdepartmental interfaces, concerned with funding research in the higher education sector, providing innovation-related and other support for enterprises, and fostering high-level human resource development by enterprise. (OECD, 2007)

To alleviate the human resources problems, the OECD report also suggests that South Africa needs to seek modification of the current immigration policy, going beyond steps that merely reduce difficulties for incoming highly skilled people, and instead develop a more proactive “green card” type of scheme that is at least as attractive to international scientific, technological and other talent as similar schemes in other countries. (OECD, 2007)

Nevertheless, there are also considerable opportunities for South Africa as an important country in Africa. South Africa has the best variety of resources in Sub-Saharan Africa and an increasing demand for science and technology.

#### **5.3.3.2 China**

The SWOT analysis presented that the Chinese NIS has characteristics with a concentration of resources. The government as the central role player in the NIS provides highly efficient and reasonable distribution downstream of the system. However, it also poses a systemic

threat in which the self-regulation capability is weaker than normal. It means that should the central resource distribution have a problem or make a mistake, it would not only influence a part of the NIS but an unbalanced problem would seriously affect the NIS and the entire economy.

An exception is the Intellectual Property Protection in China where government allows free development which is one of the aspects in which the government should play a stringent regulatory role. The fact is that China has lost control, and pirate products have formed an industry which makes the situation even more complicated. This complication means that the situation should be changed before it gets even worse, not laissez faire. At the same time, China should improve the quality of publication so that more researchers would look at it and share useful publications from China.

Compared to South Africa, China is a large and catching-up economy in that China offers large markets to poor customers and may benefit from late development. Chinese R&D intensity is relatively low, and their innovative activity also tends to be quite low compared to high income countries. The economic structure of these countries is often more geared towards low- and medium technology industries (Chang & Shih, 2004).

Generally, China seems to be doing better than South Africa, but China is also facing fatal problems in some fields. The failure of IP protection is one of the most dangerous threats to the NIS.

#### **5.3.4 Collaboration Opportunities for South Africa and China**

South Africa and China have had extensive cooperation in the science and technology field since 1999. There are 47 S&T cooperation projects running amongst universities, research institutes and enterprises. China has participated in the International Science Innovation & Technology Expo (INSITE) in South Africa since 2008.

South Africa and China are both interested in cooperation in the fields of bio-technology, mining, astronomy, palaeoanthropology, renewable resources, new material, nanotechnology, agriculture, communication, environment and climate change, etc. The new round of the South African and Chinese research cooperation joint plan will start in

2011. The new project will enlarge the cooperation area and increase yearly projects from 10 to 15 projects a year.

According to the SWOT analysis, opportunities are indicated between South Africa and China. Based on the different political systems, the governments may play different roles in each of their NIS, but policy making is one of the areas which could strengthen cooperation. The Silicon Valley model is a successful example for S&T development and technology transfer in which both South Africa and China have good universities and a sound scientific and technological base. China has rich experiences of setting Special Economic Zones that may help South Africa to boost its economy and solve the bad employment situation.

South Africa and China both have an extreme brain-drain problem. Educational communication would bring opportunities for personnel interactions, improve academic exchange and enhance understanding for both countries.

Science and technology in China has risen dramatically in the last decades, especially in the aviation, information and communication domain. On the other hand, South Africa has the best basic industry, military and agricultural technology. Tremendous opportunity and common interests exist in this area. South Africa and China should build bilateral relations of mutual benefit.

Besides, the Forum on China-Africa Cooperation has built an excellent bridge that makes the communication between Africa and China more normal. This mechanism brings more opportunities to these two BRICS countries.

In summary, South Africa and China do not have enough cooperation relative to the two countries' regional and international influence. But, it is very positive to see that both countries are BRICS countries and members of the Forum on China-Africa Cooperation. South Africa and China should find broader cooperation in many aspects.

## 5.4 Chapter Conclusion

The comparison of the innovation systems of South Africa and China has revealed that while each has unique structural characteristics, numerous complementary features also exist.

In this chapter, SWOT analysis was used to determine the characteristics of the NIS in South Africa and China. The result tried to furnish the advantages and disadvantages for the present or future development in their NIS.

At the output of the research, this chapter gave the SWOT analysis according to the horizontal comparison result between Finland, the U.S., South Africa and China.

Criteria	South Africa	China
Government Leadership	W	S
Strategy & Policies	T	S
R&D Expenditure	S	S
Human Resources	W and T	S and T
Higher Education	S or O	S
S&T Development	W	S
Paper Citation & Impact Factor	O	S
IP Right Protection	S	W and T
Technology Transfer	O	O
Government Research Institutes	S and T	S
Small and Medium Sized Organisations	O	W and O
International Cooperation	S and O	S and O
Others	-	-

Table 5.23 SWOT Analysis Summary

The SWOT analysis illustrated all the factors in the criteria of the NIS in South Africa and China, as well as the many factors that can not only influence NIS development, but which exist in the specific country, or in both countries, but which influence only a specific country.

This chapter suggests collaboration opportunities after the analysis of each advantage and disadvantage and tries to determine dual advantage points, based on collaboration for the NIS.

## **6. Validation**

This chapter verifies the research process of this thesis. It validates the methodology, criteria and analysis process.

The validation also uses an interview method to verify that the thesis covers some facts in the NIS of South Africa and China.

## 6.1 Validation Method

To test the validity of the National Innovation System research process, the validation process will be verified by means of interviews. The purpose of doing this validation is to verify that the study of this thesis matches the facts properly and that the analysis and conclusion follows the research methodology scientifically.

The hypothesis of the research stated that:

**“By documenting the characteristics of the National Innovation Systems of China and South Africa for identified criteria, it is possible to understand the differences and identify strengths, opportunities, weaknesses and threats.”**

With regard to the final validation, a description of the interviewees and their background can be found in Table 7. The focus of the interview will be relevant to each interviewee’s background.

The process of the validation involving assessing the validity is not only the methodology, but also the criteria and the advantages and disadvantages that should be considered.

The validation methodology is to interview experts, who may be involved with NIS or whose business plays a role in the NIS. The validation will interview different experts from different perspectives, which means that each expert may give his/her individual opinion on the specific part of his/her job that links to this section of the thesis.

Due to the international background of the study, the interview will be done in both South Africa and China.

## 6.2 Validation Process

The validation process includes selected experts, the questionnaire and feedback from experts. The experts will be chosen according to their background and occupation.



### 6.2.1 Survey Questionnaire

A questionnaire was designed that could be used by selected experts in the field to complete. In designing the questionnaire, the key Research Questions identified in Chapter 1 were used as a basis, as well as the Criteria identified in chapter.

	Aspects	Questions
Q1	Criteria	To what extent do you agree that the criteria used in the thesis covered all factors about a country's NIS? Does it answer research question 1?
Q2	Government Leadership	To what extent do you agree that government should play a core role by initiating strategies and policies in NIS?
Q3		To what extent do you agree that the oversight by government is important to control the NIS?
Q4		To what extent would you agree that national R&D programmes and plans are the dynamics for NIS?
Q5	Strategy & Policies	To what extent do you agree that a bundle of good strategies are important to the future development of NIS?
Q6		To what extent do you agree on the comparison of Chinese strategies and policies which are more focused on the international status, whereupon, South African strategies are more down to earth and concentrate on employment and national economy?
Q7		To what extent do you agree about the verdict which was made about the implementation of policies in your residential region?
Q8	R&D Expenditure	To what extent do you agree that gross R&D expenditure is a scale for NIS activity?
Q9		To what extent do you agree that the percentage expenditure of GDP shows how important NIS is in a country's strategy?
Q10		To what extent do you agree that foreign investment figures show the attractiveness of a country to the NIS?
Q11	Human Resources	To what extent do you agree that FTE R&D Personnel statistics show how the relative activeness of the S&T development contributes to a country? What about the per capita?

	Aspects	Questions
Q12		To what extent do you agree that the brain-drain problem is a serious problem happening in both countries and poses a big threat to NIS?
Q13		To what extent do you agree that South Africa has very low attraction for personnel, or could we say that South Africa fails us in that aspect?
Q14		Higher Education
Q15		To what extent do you agree that the enormous growth in higher education enrolment and graduation helps to show growth in delivering personnel to improve NIS?
Q16		To what extent do you agree that both South Africa and China have the ability to establish the world class universities which they need?
Q17		S&T Development
Q18		To what extent do you agree that the population influences the S&T development in China?
Q19		To what extent do you agree that South Africa should cooperate with China in the S&T sphere?
Q20		Paper Citation & Impact Factor
Q21		To what extent do you agree that the impact factors illustrate the essence of current R&D development?
Q22		To what extent do you agree that language barriers restrict the impact factor of China?
Q23		IP Right Protection
Q24		To what extent do you agree that IP protection is the biggest threat for China in the NIS?
Q25		To what extent do you agree that Chinese trade mark protection is not as bad as other IP protection, especially the protection of famous trademarks, but still it is recognised as a failure in South Africa?
Q26		Technology Transfer

	Aspects	Questions
Q27		To what extent do you agree that TT productivity is very low in China?
Q28		To what extent do you agree that there is big potential, should South Africa and China cooperate?
Q29	Government Research Institutes	To what extent do you agree that government research institutes should play the main role in S&T development in a NIS?
Q30		To what extent do you agree that South Africa makes GRIs more productive?
Q31	Small and Medium Sized Organisations	To what extent do you agree that as the dynamics of economic growth, SMEs have not developed well in South Africa and China?
Q32		To what extent do you agree that South Africa has good policies to encourage SMEs?
Q33		To what extent do you agree that the BEE policy is a threat to the SMEs in South Africa?
Q34	International Cooperation	To what extent do you agree that South Africa and China are both well involved in globalisation?
Q35		To what extent do you agree that South Africa has more regional cooperation, but China is more internationalised with it?
Q36	Other Factors	To what extent do you agree that crimes, HIV/AIDS, poverty are badly influencing the NIS in South Africa?
Q37		To what extent do you agree that South Africa and China have the same problems of corruption that hinder the NIS development?
Q38		To what extent do you agree that the population is a threat to affect the Chinese NIS?
Q39	Collaboration	To what extent do you agree that South Africa and China have opportunities to collaborate in S&T, Technology Transfer, IP protection and international cooperation fields? Does it answer research question 4?

Table 6.1 Questionnaire

## 6.2.2 Interviewee Summary

The table below gives the interviewee background and what those experts can contribute to this validation.

Interviewees	Occupation
Mr Bernard Loriol	CEO & COO of BAC fund, who has background of international business, as well as familiar with both South African and Chinese economy.
Mr Cecil Ramonotsi	PhD Student of Stellenbosch University Management School, who is currently busy with research in identifying critical success factors in technology transfer from academia to industry.
Mr David Gong	President of Tensar International (China), who has knowledge of the situation of the Chinese technology transfer and IP protection. He also has international background.
Mr Jin Cheng	Vice-Chairman of Nanda EP Technology, who has EMBA degree and familiar with Chinese SME and technology transfer policies.
Dr Louis Louw	Innovation Expert, Head of Research, Co-creator of Fugle, who is the authoritative expert of innovation and innovation system.
Prof Xu ErMing	Professor in School of Business, Renmin University of China, and the Chairman of China BELL management environment lab, who has been researching enterprise management for 15 years.
Ms Yun ZhongMei	Consultant of the government of South Africa and Owner of Accounting Service, who is a Chinese South African. She has knowledge of South African policies and strategies, as well as the China side.

Table 6.2 Introduction of Experts

## 6.2.3 Reason for Inclusion

This part gives the reasons why these experts were chosen for the validation and introduces the background of each interviewee.

### **Mr Bernard Loriol**

Mr Loriol graduated in commercial and industrial science, as well as finance, from Geneva University. His previous positions include: Trader at Commodex S.A., Head of Mocatta, Portfolio Manager at MICM S.A. and Elvia-Vie, Fund Manager at Darier Hentsch & Cie, Director of Business Development at Harcourt S.A.

Mr Bernard Loriol settled in South Africa 27 years ago. He has cooperated with Chinese investors and banks for a long time and is still seeking new collaborative opportunities between South Africa and China.

### **Mr Cecil Ramonotsi**

Mr Cecil Ramonotsi is a PhD student at Stellenbosch University, Management School, who is currently busy with research in identifying critical success factors in technology transfer from academia to industry. Mr Ramonotsi has good ideas about a national innovation system with his research background.

### **Mr David Gong**

The feedback from Mr Gong is according to his email response after we had a conversation through a phone call about this thesis. The interviewee has had much experience in the sphere of Chinese intellectual property rights. According to his background, a comparison of IP rights' protection between China and the western world is provided to validate the facts of IP rights' protection in China and to determine what might be done about it or what they should learn from the western world.

### **Mr Jin Cheng**

Mr Jin Cheng is the vice-chairman of Nanda EP Technology. He has a lot of experience of operation companies in China and is also familiar with Chinese SME policies. His background and experience enabled him to validate SME development and policies in China, as well as technology transfer and international cooperation.

### **Dr Louis Louw**

Dr Louis Louw is an expert of innovation and also the Head of Research and co-creator of the Fugle Innovation model. Dr Louw has good background to validate the methodology and many other aspects of the research.

### **Prof Xu ErMing**

Prof. Xu is the Chairman of China BELL management environment lab. He has been researching enterprise management for 15 years and was appointed as a part-time or permanent professor by 14 universities in the world, including the University of Minnesota, the University of Scranton, Euromed Marseille Ecole de Management, the University of Buffalo, the University of Technology Sydney, Hong Kong Polytechnic University, Universidade de Ciência e Tecnologia de Macau, where he lectured MBA and doctoral programmes. Professor Xu is also a member of the American Management Association.

### **Ms Yun ZhongMei**

Ms Yun is a Chinese South African who has lived in South Africa for nearly 20 years. She operates an accounting company in Johannesburg in South Africa. More importantly, she works with the South African government and used to be the adviser to the South African President about Chinese affairs.

## **6.3 Feedback on Criteria**

Each questionnaire was filled out individually by experts in the following sections. All feedback from experts will be summarised, including the motivations.

### **Government Leadership**

The questionnaire feedback gave a high degree of identity generally, but Ms Yun commented that

*“China still has capacity to improve to initiate strategies and policies. Chinese government has high point to make strategies and policies, but the feedback from market still insufficient”*

To sum up, question 2, 3 and 4 had positive feedback. The average score is 4.6, 4.8 and 4.6. The detail of the average score is shown in the table summary in part 6.4.

### **Strategies & Policies**

The result and feedback for Question 4, 5 and 6, which was relative to strategies and policies, also had high scores, except for Mr Ramonotsi who gave only 2 to question 6. He argued that

*“Literature states that the SA NIS system is designed to be more Macro environment user friendly as opposed to localisation.”*

### **R&D Expenditure**

The result of this aspect was also shown to be at the conclusion of the research.

Mr Jin mentioned that

*“Cost cannot measure the contribution to the innovation of NIS properly”*

Professor Xu argued that question 8, which is relative to the gross R&D expenditure, is a scale for NIS activity. He agreed that gross R&D expenditure means a lot, but cannot say it is the scale to evaluate NIS. On the other hand, Ms Yun also commented that effectiveness should be observed.

### **Human Resources**

There are two opinions opposing each other. According to the research facts, the result of FTE R&D Personnel on gross and per capita provided different research conclusions. The argument from experts is about which result (the gross or the per capita) is more reliable.

Mr Ramonotsi commented that

*“Per Capita measurements are more reliable.”*

Prof. Xu also proposed an open question referring to question 11 that

*“You have to think: does R&D development depend on gross FTE personnel or on average?”*

Mr Yun also stated that

*“Per capita statistics cannot show the dynamic of S&T development.”*

Mr Bernard Loriol had a different opinion about the personnel attractiveness of SA and China. He commented that

*“You are right. But you didn't count natural environment, maybe? If you think about that, many people would like to stay in SA, rather than China, because of the fresh air, although the air quality in Beijing is much better than 5 years ago.”*

### **Higher Education**

Prof. Xu commented on South Africa needing more universities,

*“Numbers of universities are required according to a country's need. More universities don't mean the quality of education is good. Countries like South Africa; they maybe need more technical colleges and training schools.”*

Mr Jin argued that

*“Quantity is not exactly equal to quality”*

Mr Cecil Ramonotsi stated that

*“Education system pipelining in the value chain, re-aligning the foundation phase at school level remains a challenge. Yes, we need more universities, but quality of education at school level must be enhanced before we talk of numbers to be pipelined to universities.”*

### **Science and Technology Development**

The problem in this aspect focuses on the impact of population.

Prof. Xu mentioned that

*“Immense population brings developing opportunities to China. Narrow terms, you are right.”*

With the same opinion, Ms Yun also commented that



*"I don't think so. China has enough resources to educate the elite. Having a big base of population provides higher possibility that supplies more personnel to the society."*

Mr Bernard Loriol also agreed that

*"The power of S&T development has to do with a nation, not people."*

On the other hand, Mr Cecil Ramonotsi thinks cultures are an impact of the reality.

A big argument about the influence of the population started in this sphere. It is true that the population provided an enormous opportunity and potential for China. If all of the Chinese per capita figure would get close to South Africa's, the power of the Chinese NIS would be incredibly great after being multiplied by the population. However, the immense population also brings a barrier to development, so that it is very impossible that the Chinese per capita data would rise rapidly because of all the kinds of resources being limited. Consequently, population is a double-edged sword. According to the status quo, the per capita data are weak as they showed. However, it is also real that it would probably be an opportunity for China.

The question of the impact of the population is complex. It is probably a very interesting topic for future studies.

### **Paper Citation and Impact Factor**

In this aspect, Mr David Gong fully agreed with the research result. He commented that

*"I was a researcher. So I can say that many Chinese publications are really valuable. Such a shame they cannot be shared with the rest of world."*

Prof Xu ErMing gave the idea that both language and quality of publications influence the paper citation and impact factor in China. He mentioned as follows:

*"It influences, I'm sure. But it has more to do with the quality of our publications."*

### **Intellectual Property Right Protection**

Experts basically agreed on the research result, but had different views on the extent. For example, Mr Gong fully agreed with the aspect.

*“Can't agree more. You know everything about what happened to Tensor in China.”*

But, he also commented that:

*“I cannot agree that our trade mark protection is better than others. As for Tensor, I think you also know that there are companies trying to copy our name and trade marks. The truth is that we cannot do anything about it.”*

### **Technology Transfer**

Mr Gong, with his experienced working background in China, didn't fully agree about the result. He mentioned that:

*“I can only say that China is different. Some of them are doing really well, some parts not quite so.”*

Prof Xu, on the other hand, agreed with the result, but did not agree with the reason for the analysis. He commented that:

*“We have an industrial structure problem. It is quite complicated so you cannot just blame productivity.”*

### **Government Research Institutes (GRI)**

Mr Loriol commented about how government research institutes should play the main role in S&T development in a NIS:

*“South African GRIs have budget constraints.”*

The different voice from Dr Louis Louw argued that:

*“GRIs are not the main role players - also other bodies like Science and Technology Parks, Universities, etc.”*

### **Small and Medium Enterprises**

Mr Bernard Loriol did not agree that South Africa has good policies to encourage SMEs. He said that:

*"I don't agree with it. China is easier to do business with than America. It would be easier than SA as well".*

The feedback on Question 32 had a high variance. However, Bernard Loriol, who is the only one with experience of doing business in South Africa, China and America, strongly disagrees with the evaluation result.

The evaluation of the South African and Chinese policies' environment was according to the official report of the World Bank Group and Finance Corporation. It should be correct on a macro level. However, the opinion of Mr Loriol should also be respected and considered. Moreover, the status quo of SME development is changing all the time. The timeliness of policies may have had an influence on the evaluation and people's feelings in the past and future.

As for the BEE policies, Mr Yun said it would increase the costs of running firms. But, Mr Ramonotsi did not agree with that. He believed that BEE policies would generally encourage the SMEs developing country wide.

### **International Cooperation**

Mr Ramonotsi did not think that South Africa has more regional cooperation. He commented that:

*"BRICS-SA collaboration shows that SA is in global space."*

Except for the above comment, other experts agreed or strongly agreed with the opinions in the research.

The feedback result provided a suggestion that it is possible that cooperation opportunities exist between South Africa and China in international cooperation sphere. Bernard Loriol mentioned in relation to Q34 that:

*"Many aspects cannot compare with China."*

According to the study, the China-Africa Forum is providing a very good cooperation platform, not only with South Africa, but also covering the entire African region. South

Africa does not have similar types of cooperation mechanisms global wide, though it has to admit that South Africa is playing a very important role in the Sub-Sahara African region.

### **Other factors**

Mr Cecil Ramonotsi commented that

*"I have not seen any correlation to this effect. However, I have picked up supply chain challenges in the literature that I have worked through to date. These challenges are not relating to governance but are referring to impediments on facilitating technology transfer among and between firms and institutions of higher learning."*

Cecil also commented about the influence of population in Chinese NIS,

*"In fact, it is a strength, it offers a competitive advantage or temporary advantage in a sense that strategies to compete change every minute or every few seconds in business circles."*

Mr Jin also argued about the population issue:

*"Population brings a big market and opportunities to Chinese economic growth."*

However, Ms Yun argued that

*"...for the entire system, I agree. India is an example."*

## **6.4 Summary of the Validation**

All experts agreed with the methodology in the thesis and basically agreed about the criteria in the research. Some of the different opinions about criteria were actually mentioned in lower levels of the criteria or in the other factor section. For example, Dr Louw stated that he thinks that there are some missing indicators of the knowledge flows within National Innovation systems, such as industry alliances, university/industry interactions, personnel mobility, etc. However, the university/industry interaction was mentioned in criterion technology transfer and personnel mobility was presented in the human resources part and also in the brain-drain problem.

The most disagreements concentrated on the analysis result of the population (e.g. Q18). According to the quantitative analysis, the capita outputs were negative for the most of the

results on the China side. The research didn't not have enough capacity to go into more detail where and how the population influences the NIS. The result of the SWOT analysis just gave a statistic reality. However, the thesis mentioned that some of the aspects could be an "opportunity" with this population influence in the SWOT analysis.

The table below presents a summary of the interviewees' feedback.

	Bernard Loriol	Cecil Ramonotsi	David Gong	Jin Cheng	Louis Louw	Xu Erming	Yun Zhongmei	Average
Q1	4	3	5	4	3	4	5	4.00
Q2	5	4		5	5	5	4	4.67
Q3	5	4		5	5	5	5	4.83
Q4	5	4		5	4	5	4	4.50
Q5	5	4	5	3	5	4	5	4.43
Q6	5	2	5	4		4	5	4.17
Q7	5	3	4	4	3	5	5	4.14
Q8	5	4		3	4	3	5	4.00
Q9	5	4	4	4	4	4	5	4.29
Q10	5	4	3	5	5	4	5	4.43
Q11	5	4			4	4	4	4.20
Q12	5	4	5	4	4	5	5	4.57
Q13	3	3			4			3.33
Q14	2	4		3	2	3	5	3.17
Q15	3	4		4	4	3	5	3.83
Q16	5	4		5	4		4	4.40
Q17	4	3			5		5	4.25
Q18	3	2			3	3	1	2.40
Q19	5	4		5	4	4	5	4.50
Q20	5	3		5	3	4	5	4.17
Q21	5	4			3	4		4.00
Q22	5	3	5		3	3	5	4.00
Q23	5	4		5	3		5	4.40
Q24	5	4	5	5	3	5	5	4.57
Q25	5	3	5	4		4		4.20
Q26	5	3		5	4	3	5	4.17
Q27	5	2	3	3		2	3	3.00

	Bernard Lorial	Cecil Ramonotsi	David Gong	Jin Cheng	Louis Louw	Xu Erming	Yun Zhongmei	Average
Q28	5	4			5	3	2	3.80
Q29	4	4			2	5	5	4.00
Q30	5	4			3	4		4.00
Q31	5	4	4	5	4	5	4	4.43
Q32	1	4		5	2		5	3.40
Q33	4	2		5	4		5	4.00
Q34	3	4	5	5	3	5	5	4.29
Q35	5	2	4		3	5	5	4.00
Q36	5	3	4	5	4	4	5	4.29
Q37	5	2	5	5		4	5	4.33
Q38	5	2	2	3		3	5	3.33
Q39	3	3	4	5	4	4	5	4.00
Average	4.46	3.38	4.28	4.41	3.68	4.00	4.60	4.12

Table 6.3 Summary of Validation

The validation feedback generally provided a positive result. According to Table 6.3 Summary of Validation, the average score of the validation process is 4.12, after summarised feedback from 7 experts. The most of the arguments are around the population factors and the technology transfer aspect.

## 6.5 Chapter Conclusion

All the criteria have been validated, including the conclusion and recommendations, and the overall feedback was positive.

The recommendations, opinions and motivations of the experts were taken into account and the variations in opinions were analysed and incorporated into the framework. Different opinions occurred where the experts had different views and a differing understanding of the different field. This led to interesting discussions by experts that might inspire new research topics.

According to the discussions and questions from experts, some future studies might include the following aspects:

- Culture factors
- International background
- Population influence

The future work will be discussed in more detail in the chapter 7.

## **7. Conclusion**

The final chapter presents a conclusion of the methodology process used and summarises the research result, as well as the result obtained from validation.

The final section of the chapter highlights certain focus areas that may provide possible opportunities for future related research.



## 7.1 Research Method Conclusion

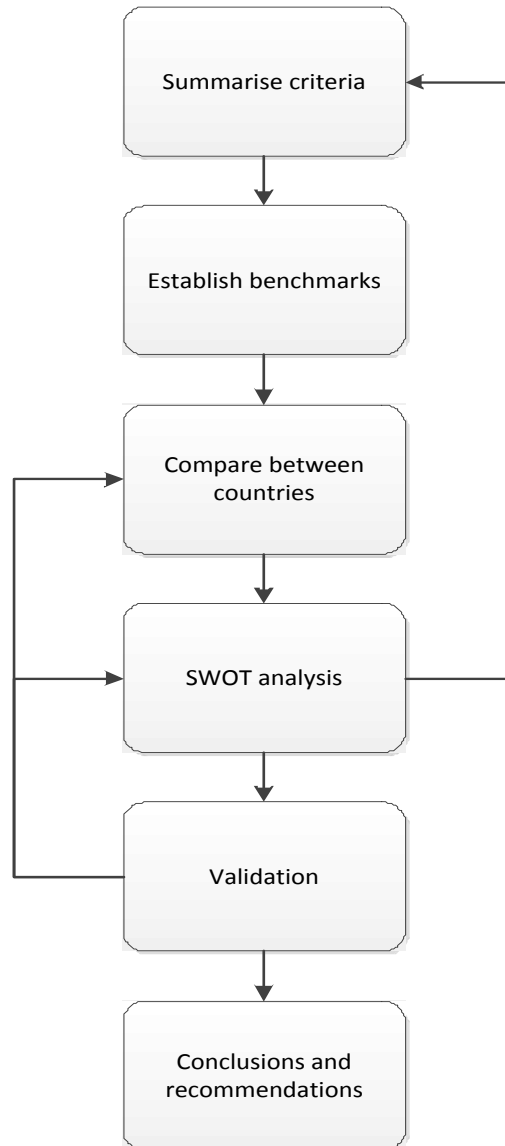


Figure 7.1 Research Method Flow

This research not only focused on the comparison of South Africa and China, but also compared these two countries in a global context. The evaluation given in the SWOT analysis was the result after comparing Finland and America. It also included other international background so that the conclusion could provide more persuasive details.

The different contributions made by every chapter in this thesis are illustrated in the table below and it represents the explanation which was given in Chapter 1.

	Literature Review	Summarised Criteria	Comparison	SWOT Analysis	Validate Process
Chapter 1	✓				
Chapter 2	✓				
Chapter 3	✓	✓			
Chapter 4	✓	✓	✓		
Chapter 5				✓	
Chapter 6					✓
Chapter 7					✓

Table 7.1 The Research Methodology Completed

## 7.2 Research Conclusion for Research Questions

The validation process verified the answers to the research questions in the study.

- What criteria must be used to identify the characteristics of a NIS?

The 12 criteria used to analyse the NIS of South Africa and China were identified in Chapter 3. The table below shows the criteria.

	Identified Criteria
1	Government Leadership
2	Strategy & Policies
3	R&D Expenditure
4	Human Resources
5	Higher Education
6	S&T Development
7	Paper Citations & Impact Factor
8	IP Right Protection
9	Technology Transfer
10	Government Research Institutes
11	Small and Medium Sized Organisations
12	International Cooperation

Table 7.2 Identified Criteria

There were 9 other factors involved that also influence the NIS, but which are not commonly used to compare NISs. These 9 factors were mentioned in Chapter 5 and included HIV/AIDS, the ageing population, crime, corruption, the gap between rich and poor, poverty, Public Health, etc.

- In terms of these criteria, what are the main differences between South Africa and China?

The main differences in the 12 criteria between South Africa and China are strategy focuses, intellectual property protection and higher education systems.

- What are the advantages and disadvantages in the NIS of South Africa and China?

In Technology Transfer, Paper Citation and Impact Factor, SMEs development, IP Protection and International Cooperation spheres, the South African NIS shows excellent performance and keen competitiveness.

On the other hand, R&D Expenditure, Human Resources, Higher Education, Science and Technology Development, as well as aspects of Quality of Public Education indicate areas in which South Africa needs to improve.

China has advantages in Government Leadership, Strategy & Policies, R&D Expenditure, Human Resources, Science and Technology Development, Government Research Institutes and International Co-operation.

However, Paper Citation and Impact Factor, Small and Medium Enterprises, Intellectual Property Right Protection and Technology Transfer are weaknesses in the Chinese NIS.

- Which collaborative opportunities exist between South Africa and China in the innovation field?

South Africa and China are both interested in cooperation in the fields of Bio-technology, mining, astronomy, palaeoanthropology, renewable resources, new material, nanotechnology, agriculture, communication, environment and climate change.

South Africa and China do not have enough cooperation which is relative to both countries' regional and international influence. However, it is very positive to see both countries are members of BRICS and the Forum on China-Africa Cooperation. South Africa and China could find broader cooperation opportunities in many aspects.

- What and how can South Africa and China improve their NIS?

### **South Africa**

To alleviate the human resources problems, the OECD report suggests that South Africa needs to seek modification of the current immigration policy, going beyond steps that merely reduce difficulties for incoming highly skilled people, and instead develop a more proactive "green card" type of scheme that is at least as attractive to international scientific, technological and other talents as similar schemes in other countries.

### **China**

An exception is the Intellectual Property Protection in China, of which government allows free development and which is one aspect in which the government should play a stringent regulatory role. The fact is that China has lost control, and pirate products have formed an industry which makes the situation even more complicated. This complication means that

the situation should be changed before it gets even worse, and not develops into laissez faire. Meanwhile, China should improve the quality of publications which would be useful for more researchers to study and share.

### 7.3 Conclusion and Recommendation

Following one of the NIS definitions, a National Innovation System can be thought of as a set of functioning institutions, organisations and policies, which interact constructively in the pursuit of a common set of social and economic goals and objectives. The summary of the thesis has consistency with the definition and can be summarised as the following figure.

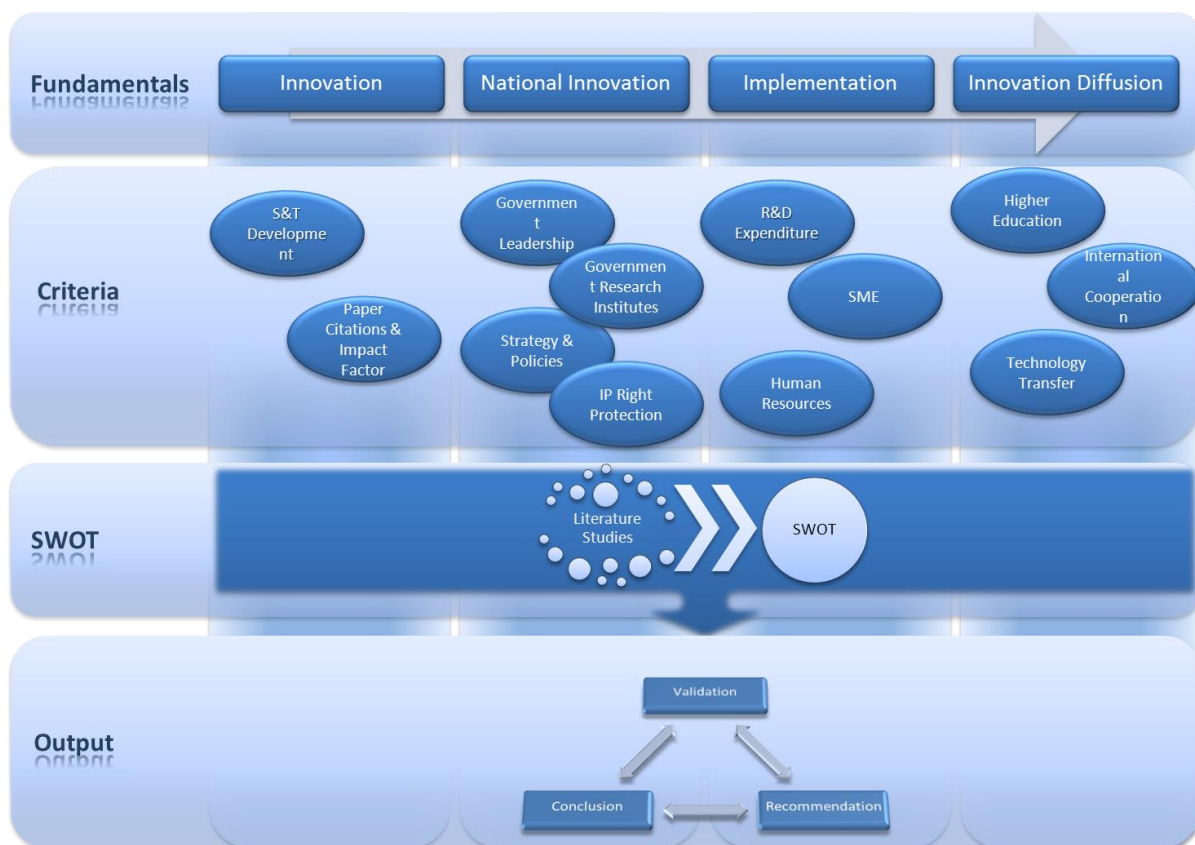


Figure 7.2 Research Structure

Figure 7.2 illustrates the research structure that been completed in the thesis. The figure also presents the relationship between various parts.

## South Africa

For the NIS to become effective and efficient, all South Africans should participate. This requires a society which understands and values science, engineering and technology and their critical role in ensuring national prosperity and a sustainable environment. This, in turn, requires that S&T information be disseminated as widely as possible in ways that are understood and appreciated by the general public.

Further recommendations are that South Africa should find more opportunities by cooperation with other OECD countries outside the European Union and China. Technology development is showing a trend in which the east is starting to play the main global role.

The question of how to keep South Africa's R&D moving forward focuses on the brain-drain problem which has existed for quite a long time. To counteract this trend the affected countries are attempting a range of interventions, for example, Canada has set aside funds for the creation of two thousand university seats in science and engineering over the next five years. Both France and Germany are in the process of radically overhauling their legislation and practices to promote science-industry linkages in line with the United States' highly successful Bayh-Dole Act.

Besides, South Africa urgently needs to improve the sustainability of economic development. To reach that, the South African government should develop more far-sighted policies. They should try to get rid of a single development model structure that is too dependent on agriculture, mining and tourism. A good industrial base should be used to develop high-tech manufacturing and sustainable developing industry. Developing high value added industries probably is the only way to solve the conflict between rising labour cost and employment.

## China

The Chinese National Innovation System has been an embarrassing situation. The country has granted many patents, but few of them are creative. China has a big amount of R&D expenditure, but only 4.8% of the expenditure was spent on basic research. It has broken the law of scientific development, so sustainability thereof is in doubt. The core problem in the Chinese NIS, except for the IP protection which was mentioned in Chapter 5, is to

improve quality instead of pursuing quantity. To solve this problem will involve systemic and even cultural issues. Not many research studies have been done with regard to this issue in China. It is recommended that more studies should be done in future.

In addition, China has started to pay more attention to the development of SMEs. Given the status quo in terms of current SME development in China, China can still accomplish a great deal. China needs to focus on the quality of SME development and not only rely on the quantity of SMEs. It may be worthwhile to provide more support for SMEs in the high technology fields. China also needs to ensure that more talent returns to China to help with this development.

## **7.4 Future Research**

The political issues involved everywhere in the NIS, especially in South Africa and China, two quite unique countries, presented an unavoidable difficulty during the study. In the beginning, the intentions of this research was not to discuss politics, however, as the study process progressed, many issues pointed to political systems and not to innovation systems.

The other crucial question is culture. This means that the approach of doing things in China, Japan, the USA and South Africa will be significantly different (i.e. work ethics is not the same). The difference is not applicable to this study. However, it would be interesting to discover the influence of culture on the NIS and cooperation. This would help to improve communication and efficiency between and among countries.

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## Appendix I

# **NATIONAL INNOVATION SYSTEM: SOUTH AFRICA & CHINA COMPARED**

Validation Background Information

October 2011

**Jeremy Zhang**

[zhy@sun.ac.za](mailto:zhy@sun.ac.za)



## Introduction

### Background of NIS

In broad terms, a national innovation system (NIS) can be broadly defined as all economic, political and other social institutions affecting learning, discovery and exploring activities (i.e. a nation's universities and research bodies, financial system, its monetary policies, and internal organisation of private firms).

The following elements are usually considered part of a National Innovation System:

- 1) Education and training. Government is in general responsible for education at different levels, which is considered to be the key in the production of sufficient human skills and crucial for the production and diffusion of knowledge.
- 2) Science and technology capabilities. The resources invested in R&D, both public and private, differ between countries. It is generally hypothesised that the innovations correlate with the R&D expenses.
- 3) Industrial structure refers to the number of competitors in an industry, their size and their relationships. In general it is hypothesised that strong competition among large firms favours investments in R&D and imitation in particular products and processes.
- 4) Countries differ in degree of specialisation and intensity of R&D expenditures in specific areas. Often government plays an important role in creating a competitive advantage of a NIS in a specific area.
- 5) Interactions within the innovation system seem important for the level of R&D activities and the diffusion of knowledge. (Porter M. E., 2001)

Consequently, the National Innovation System is not simple. NIS can be broadly defined as all economic, political, financial, educational and other social facilities affecting searching, developing and exploring activities. It includes a nation's research and university bodies and fiscal and policy making systems etc. All these things work together and influence a nation's innovation system.

The National Innovation System (NIS) drives economic growth and ultimately determines the country's living standards and those of its metropolitan areas. Nowadays however, the country faces a growing innovation challenge in global economy.

The study of the National Innovation System focuses on flows of knowledge. Analysis is increasingly directed to improving performance in "knowledge based economies" –



economies which are directly based on the production, distribution and use of knowledge and information (OECD, 1996b).

## Purpose of the Research

The purpose of this study is to find out how both countries use an innovation system to improve the competitiveness of each country and how they are operating the national innovation. The purpose of the study is to try to find out the difference and the gap between these two countries and other more innovative countries, as well as the difference and the gap between South Africa and China. Some recommendations will be made at the end of the study.

## Research Method

The aim of the evaluation of NIS is to provide insights into how the National Innovation System, its structure and organisations can respond to the changes in the global environment and to the challenges these changes pose.

The hypothesis of this thesis is

**“By documenting the characteristics of the National Innovation Systems of China and South Africa for identified criteria, it is possible to understand the differences and identify strengths, opportunities, weaknesses and threats.”**

All the main characteristics of each country normally are major issues and the bottleneck of their economy as well. The factors have to be analysed particularly. This thesis will highlight that China and South Africa, as two developing countries, can learn from Finland and the US, or others just as good as them, who have been classified as showcase examples for successful National Innovation Systems.

There are some questions which have to be answered during the research process:

1. What criteria must be used to identify the characteristics of a NIS?
2. In terms of these criteria, what are the main differences between South Africa and China?
3. What are the advantages and disadvantages of NIS in South Africa and China?
4. What collaborative opportunities exist between South Africa and China in the innovation field?
5. What can South Africa and China do to improve their NIS?

To achieve the purpose above, the research method has been designed in 5 steps.

Firstly, a domain research to calculate the targeted objects and information will be introduced.

Secondly, criteria will be summarised from literature which illustrates the findings of research studies about National Innovation Systems and the comparisons of NIS between nations. The reason for that is because the definition, which will be mentioned in the next chapter, is not clear enough to be a benchmark to evaluate the standard of NIS. Through the pre-study of other research, it is not difficult to see that the understanding of National Innovation Systems in different countries is dissimilar consequently there seems no mutual standard for the following comparison.

Thirdly, the summarised criteria will be used as a benchmark. Countries will be horizontally compared considering all these factors. In the end, a summary will be given to show the difference between the countries being compared.

After that, a SWOT analysis method will be used to analyse the advantages and disadvantages according to the information that has been given in the comparison. The result will cover the main characteristics of the South African and Chinese Innovation System and show similarities and differences.

The final step of the process will be to verify that the research covers all the questions and to conclude the logical loop.

## Your Role

Your input will be appreciated concerning the applicability and usability of the NIS. You will be required to evaluate the criteria and other aspects that are relevant to your background. You may fill in 'unknown' should the question not relate to your background or if you have no idea about the factor, however, you will still be welcome to make any comments in the motivation block.

The background of my study will be delivered in this review. The interviewees are required to answer and evaluate the aspects relevant to your own background or experienced fields on a scale of 1~5, with 5 being 'strongly agree' and 1 being 'strongly disagree'.

## Background Information

### Criteria Identified

The arguments presented to discuss the NIS of South Africa and China required a new approach to a comparison analysis, because the understanding of the NIS definition was not absolutely the same in all countries resulting in their arguments not relating to all economic and cultural backgrounds. This meant that the criteria for comparison needed to be investigated.

### Focus

The objective of the thesis will focus on comparison of the National Innovation System. The differences and gaps between South Africa, China, Finland and USA will be analysed during the comparison section. Moreover, the thesis will revert to determine what the situation of the Innovation System of South Africa and China is and try to analyse the reason why they happened or why they are happening from different perspectives.

Some criteria will be established through the study of literature written by previous researchers and comparison studies of the National Innovation System. These criteria will be used by analysing the innovation differences between each country.

### Selection of NIS

It is difficult to say which country has the best national innovation system. Even the country which is the most developed country in the world. So in this study, two countries will be used to be the benchmark which will help to analyse the NIS of South Africa and China.

As other researchers usually do, it is easy to look at ranks and decide which countries have mature innovation systems.

Country	Growth Competitiveness ranking 2003	Growth Competitiveness ranking 2003 among GCR 2002 countries	Growth Competitiveness ranking 2002
Finland	1	1	1
United States	2	2	2
Sweden	3	3	3

Country	Growth Competitiveness ranking 2003	Growth Competitiveness ranking 2003 among GCR 2002 countries	Growth Competitiveness ranking 2002
Denmark	4	4	4
Taiwan	5	5	6
Singapore	6	6	7
Switzerland	7	7	5
Iceland	8	8	12
Norway	9	9	8
Australia	10	10	10
Japan	11	11	16
Netherland	12	12	13
Germany	13	13	14
New Zealand	14	14	15
United Kingdom	15	15	11

Table 0.1 Growth Competitiveness (OECD, 2004)

Table 3.1 clearly illustrates that Finland and the US are leading the growth competitiveness in the world. The core reason of their high growth competitiveness is because of their mature National Innovation System and sufficient government monetary investment. Finland posted improvements in its overall macro-economic stability characterized by an increase in its government surplus, an increase in its national savings rate, and further reduction of its inflation rate and interest rate spread.

To establish a criterion for easy comparison of innovation differences, Finland and the United States have mature national systems as the best option for the comparison of China and South Africa's NIS. The criterion will be established based on analysis of both advantages and disadvantage of the national systems of Finland and the US.

### Criteria Identified

The methods of comparison and focus countries were pointed out and the criteria were identified by means of literature studies. The following table shows the summarised criteria.

	Identified Criteria
1	Government Leadership
2	Strategy & Policies
3	R&D Expenditure
4	Human Resources
5	Higher Education
6	S&T Development
7	Paper Citations & Impact Factor
8	IP Right Protection
9	Technology Transfer
10	Government Research Institutes
11	Small and Medium Sized Organisations
12	International Cooperation

Table 0.2 Selected Criteria

The criteria above were identified by analysed normal and frequent NIS research criteria that are usually used or referenced.

### SWOT Analysis

In this part, South Africa and China will be analysed together according to each criterion. That is because by comparing both of them, similarities or differences or opportunities for cooperation can be discovered. At the end of each criterion, a conclusion will be given with a table that explains the motivation for the conclusion and the process of reaching the final conclusion of the SWOT analysis.

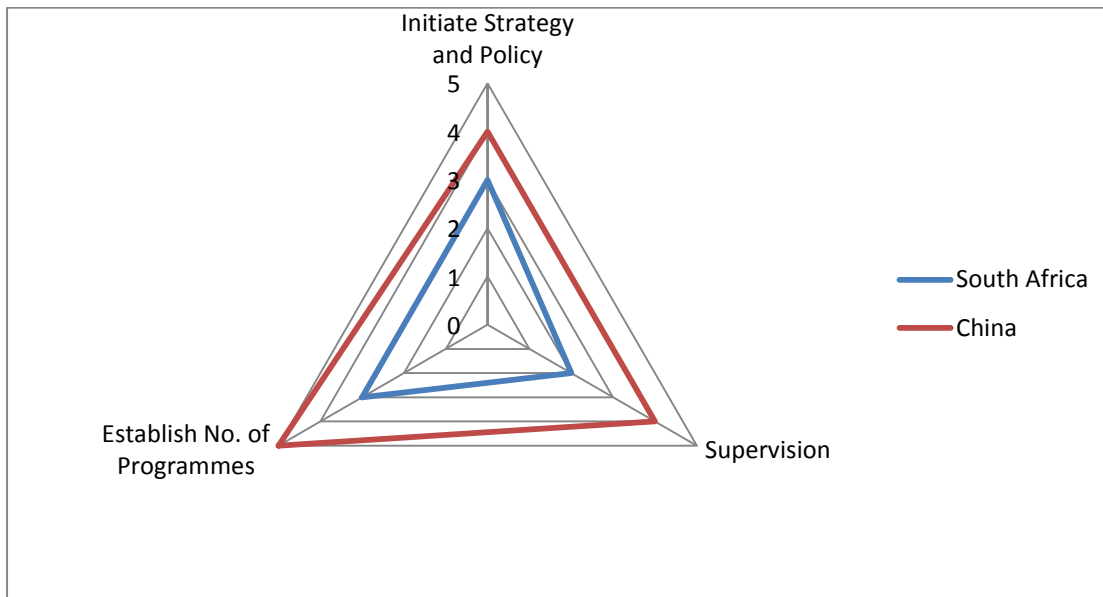
The result will be shown in a table for each aspect of the criteria and be marked from very bad, poor, moderate, good to excellent. The average for each aspect will be summarised according to each one. The conclusion of Strength, Weakness, Opportunity or Threat will be given according to this score.

In order to provide a more immediate comparison to the NIS analysis, the basic analysis results will be presented in star diagrams. According to the analysis above, the levels, very bad, poor moderate, good and excellent will be transferred to a score of 1 to 5.

### Governmental Leadership

The social and political institutions of the NIS function as the institutional selection environment of innovation processes in a country (Groenewegen & van der Steen, 2006). Government policy has unified to target specific groups of entrepreneurs, such as the historically disadvantaged, women, youth or the disabled, who are more likely to be poor and unemployed or without opportunities. (OECD, 2007) Allocating resources to these groups involves a trade-off between job creation and redistribution. Regardless of priorities, improved educational access, improved mathematics and science teaching and entrepreneurship education are crucial.

Aspects	South Africa	China	Note
Initiation of Strategy and Policy	Moderate	Good	South Africa was the first country in the world to adopt this framework as its national policy. The Chinese government continues to play a central role in the development of science and technology as well as in promoting high-tech industry innovation.
Supervision	Poor	Good	There is no measurement which can be used as a reference to show how the implementation of supervision is done by the South African government at present. The Chinese government set a goal to supervise the R&D development and controls the factors that influence the R&D.
Establishing the number of Programmes	Moderate	Excellent	South Africa has an advanced strategy which is called the Advanced Manufacturing Technology Strategy (AMTS) Many programmes were established in China promoting S&T development.
<b>Overall</b>	<b>Moderate</b>	<b>Good</b>	
<b>Government Leadership</b>	<b>Weakness</b>	<b>Strength</b>	



## Strategies and Policies

The strategies and policies made by South Africa are judged between the levels of strength and weakness. Conversely, the threat from over protection to non-white people and unskilled workers may cause a more serious and unbalanced problem. Therefore, the sector of strategies and policies were evaluated as a threat for SWOT.

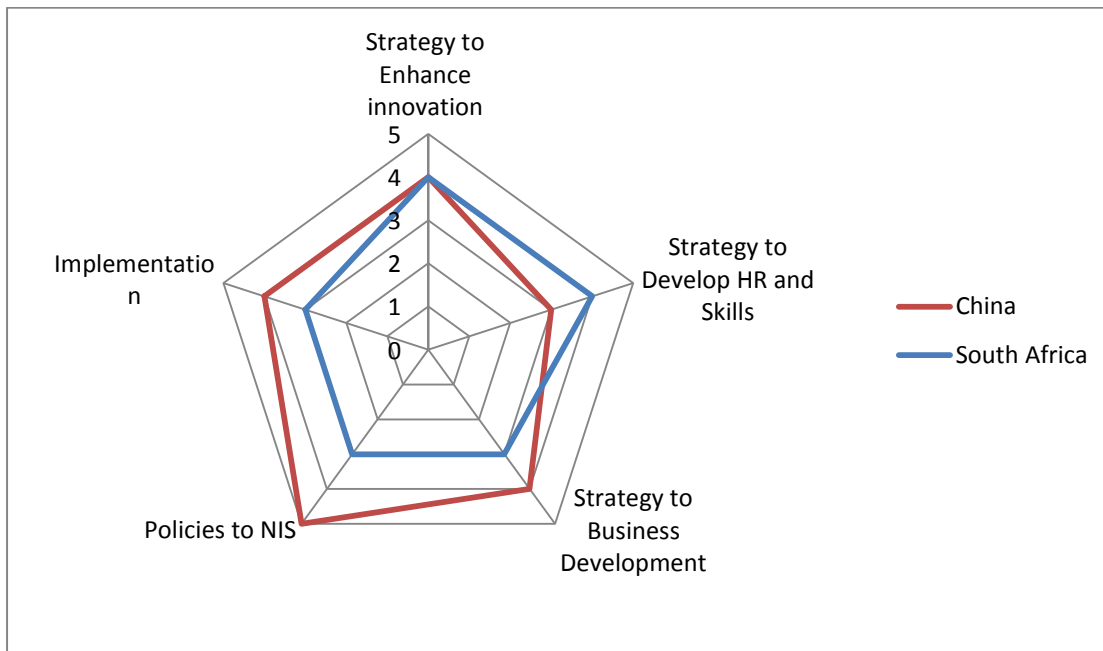
To sum up, the South African innovation strategy focuses more on the domestic demand which means the demand for the social development, unemployment and poverty. It is a strategy to solve existing social contradiction. The strategy matches the situation of South Africa's economic growth and other social problems at grass-roots level.

On the other hand, the Chinese innovation strategy has a higher aim. It is based on the global strategy and gives obvious ranking requirements which may not be necessary. The strategies are good, but if the purpose was not to compete with other developed countries, but to consider the country's demand, it would be an even better strategy. However, it also shows the powerful ability of making strategies.

An obvious Chinese strength in the innovation system is that China has been concentrating on government strength and that policies which have been made have aims, and that operators use policies effectively.

Aspects	South Africa	China	Note
Strategies to Enhance Innovation	Good	Good	The innovation towards a knowledge-based economy plan aims to drive South Africa's transformation towards a knowledge-based economy. The key word in Chinese innovation strategy is 'indigenous innovation'.
Strategies to HR & Skills	Good	Moderate	This strategy is trying to provide a plan to ensure that people are equipped to participate fully in society in the next 20 years, to be able to find or create work, and to benefit fairly from it. China has a specific HRD strategy which is a very high priority as far as the government is concerned, but is facing challenges.
Strategies to Business Development	Moderate	Good	The national strategy for the development and promotion of small business identifies the creation of new black-owned and black controlled enterprises as a key issue.
Policies to NIS	Moderate	Excellent	BEE policy of South Africa poses a massive threat to economic growth. China has formulated and implemented the "Scientific and Technological Progress Law" and the "Scientific and Technological Achievements Law" as well as other laws and regulations
Implementation	Moderate	Good	The implementation of such policy changes was uneven and tended to concentrate on the upstream part of the innovation value change, namely in R&D areas.
<b>Overall</b>	<b>Moderate</b>	<b>Good</b>	
<b>Strategy and Policy</b>	<b>Threat</b>	<b>Strength</b>	





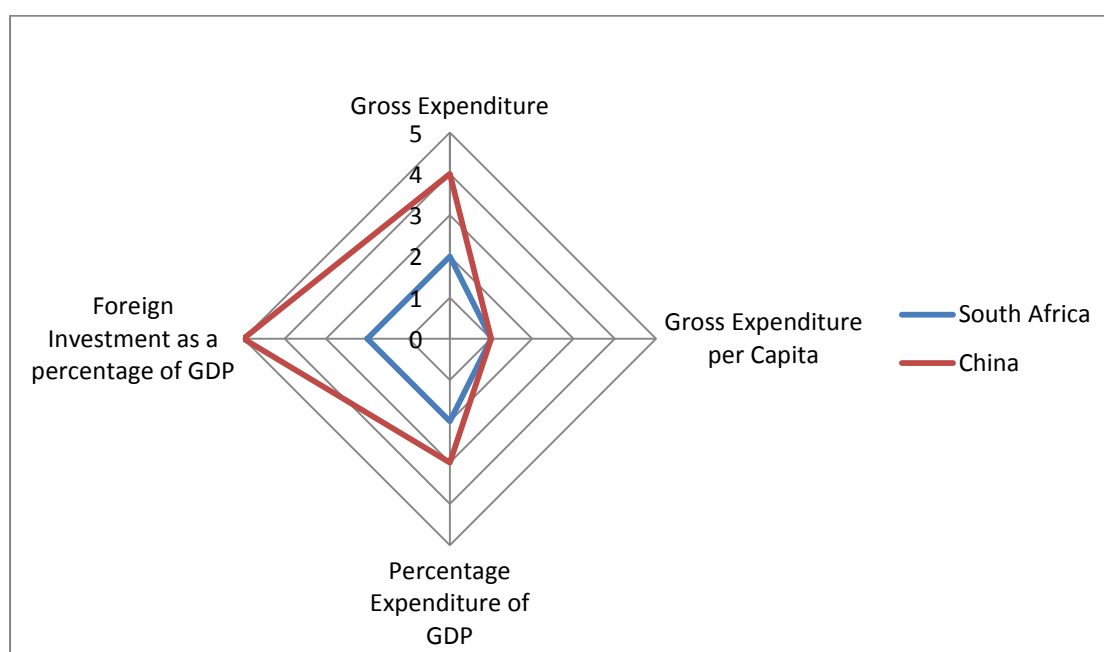
## R&D Expenditure

South Africa's large proportion of business enterprise expenditure on R&D in total R&D expenditure is a virtue and reflects industry's ability to build on existing strengths, especially in resource intensive branches, and to develop bigger clusters of capability. (Department of Science and Technology of South Africa, 2007)

One thing has to be considered in this sector, the South African economy is based on energy, agriculture and mining, which are traditional industries which differ from communication and electronic products, for example, as in Finland's economy as we discussed.

Aspects	South Africa	China	Note
Gross Expenditure	Poor	Good	South Africa: over R18.6 billion China: ¥ 461.6 billion=\$ 69.3 billion both in 2008 U.S.: \$343 billion in 2006 Finland: € 6.9 billion in 2008
Gross Expenditure per Capita	Very Bad	Very Bad	China's gross expenditure per capita is about 53.1. South Africa's gross expenditure per capita is 55.3 dollar. The US gross expenditure per capita \$1,143,333 in 2006 Finland's gross expenditure per capita \$1,301,887 in 2008.

Aspects	South Africa	China	Note
Percentage Expenditure of GDP	Poor	Moderate	South Africa: 0.92% China: 1.44% U.S.: 3.49% Finland: 2.77% in 2008
Foreign Investment as a percentage of GDP	Poor	Excellent	South Africa's gross savings as a percentage of gross domestic products (GDP) was 14.8% in 2007, compared to countries such as China (54.1%).
Average Credit	Poor	Good	
R&D Expenditure	Weakness	Strength	



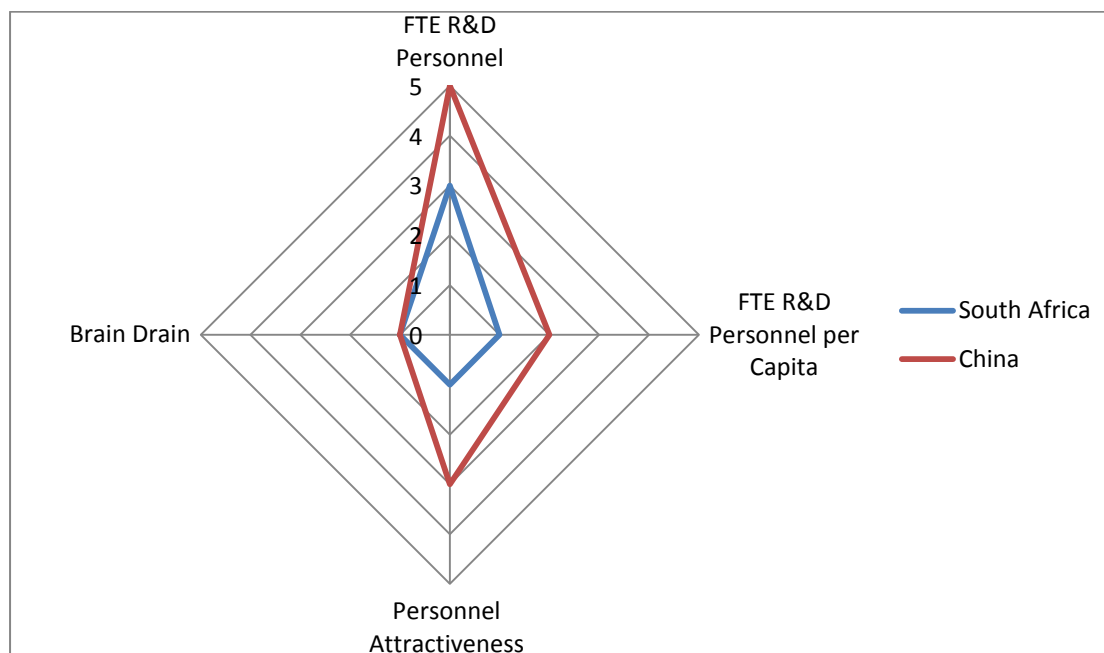
## Human Resource

The South African government regards human resources as their national asset. The concept of human resource development (HRD) refers to the process whereby people, either individually or collectively, acquire the knowledge and skills necessary for specific occupational tasks as well as for other social, cultural, intellectual or political roles associated with a vibrant democratic society (Department of Science and Technology of South Africa, 1996; Department of Science and Technology of South Africa, 2007). However, the reality is South Africa is facing a serious brain-drain problem not only because of political reasons.

The large number of R&D personnel is one of the most important strengths for China in its S&T development. Human resources are at least as important as capital inputs and are a crucial building block in S&T development. The large number of R&D personnel is one of the most important strengths for China in its S&T development.

The final result of the human resource situation of South Africa and China is dramatically different. South Africa is facing an extreme lack of personnel and a brain-drain problem. This problem may result in limited NIS development potential for years and drag the NIS development into a vicious circle. Here China is a good example for South Africa. To keep investing in the education and side industry, China is building a world-class academia and increasing its attractiveness. The table below gives the analysis result of this part.

Aspects	South Africa	China	Note
FTE R&D Personnel	Moderate	Excellent	Total of 31,352 FTE R&D personnel in South Africa and the total of FTE R&D personnel is 1.9 million in China ranked 1 <sup>st</sup> in the World. Finland has 40,900 FTE R&D personnel.
FTE R&D Personnel per Capita	Very Bad	Poor	South Africa has 0.64 FTE personnel for every 1000 people and China has 1.45 FTE personnel for every 1000 people. Finland has 7.71 FTE personnel for every 1000 people
Personnel Attractiveness	Very Bad	Moderate	The number of foreign students who came to China for higher education reached 141,087.
Brain Drain	Very Bad	Very Bad	There were 718 000 highly skilled Chinese-born residents in OECD countries
<b>Overall</b>	<b>Very Bad</b>	<b>Moderate</b>	
<b>Human Recourses</b>	<b>Weakness &amp; Threat</b>	<b>Strength &amp; Threat</b>	



## Higher Education

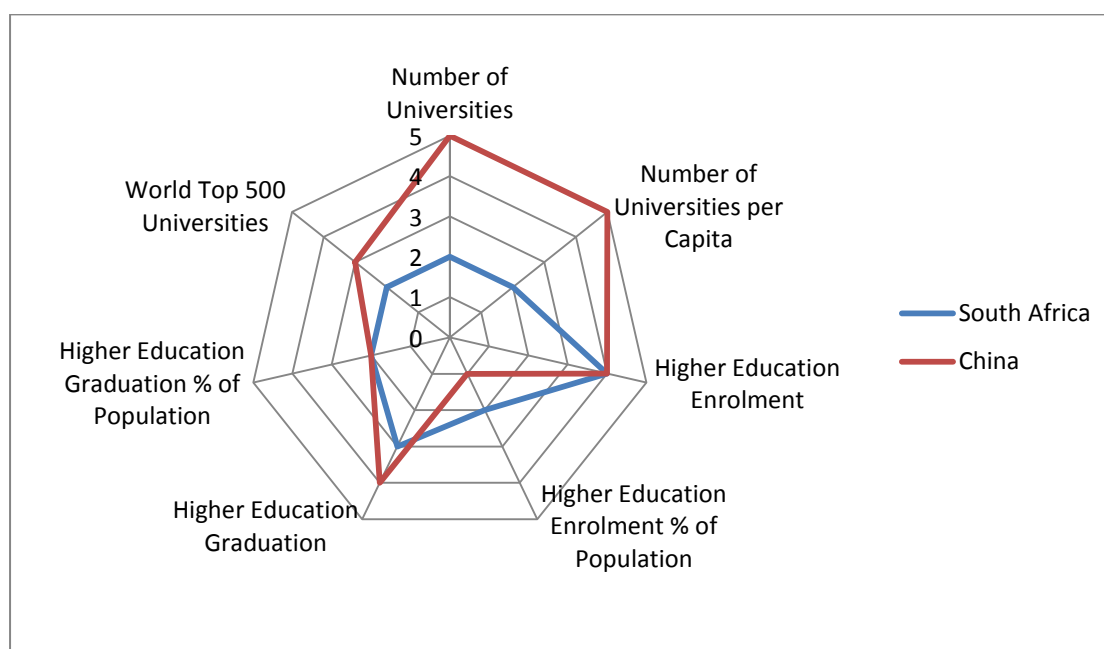
South Africa's higher education rate is not every high compared to the US and China, but it does have very good educational resources and wide international cooperation. South Africa also has widely popularized colleges to train labour capabilities to the people who need jobs. To sum up, South Africa has a very healthy and well-classified higher education system that can provide the necessary highly-skilled people to society.

China has enough colleges and universities. These will help China to improve education and supply skilled-people to society in the future.

The table below gives the analysis result of the Higher Education aspect.

Aspects	South Africa	China	Note
Number of Universities	Poor	Excellent	21 public universities including 5 universities of technology in South Africa and 2,236 colleges and universities in China.
Higher Education Enrolment	Good	Good	In 2008, there were 799,387 students enrolled in South Africa and 3,074,741 students in China
Higher Education Enrolment % of Population	Poor	Very Bad	1.63 per100 people in SA and 0.24 per 100 people in China.
Higher Education	Moderate	Good	In 2008, 133,063 students graduated in South Africa and 2,256,783 students

Aspects	South Africa	China	Note
Graduation			graduated in China
Higher Education Graduation % of Population	Poor	Poor	0.27 per 100 people in SA and 0.17 per 100 people in China.
World Top 500 Universities	Poor	Moderate	South Africa has 3 universities and China has 12 listed.
<b>Overall</b>	<b>Moderate</b>	<b>Good</b>	
<b>Higher Education</b>	<b>Weakness &amp; Threat</b>	<b>Strength &amp; Opportunity</b>	



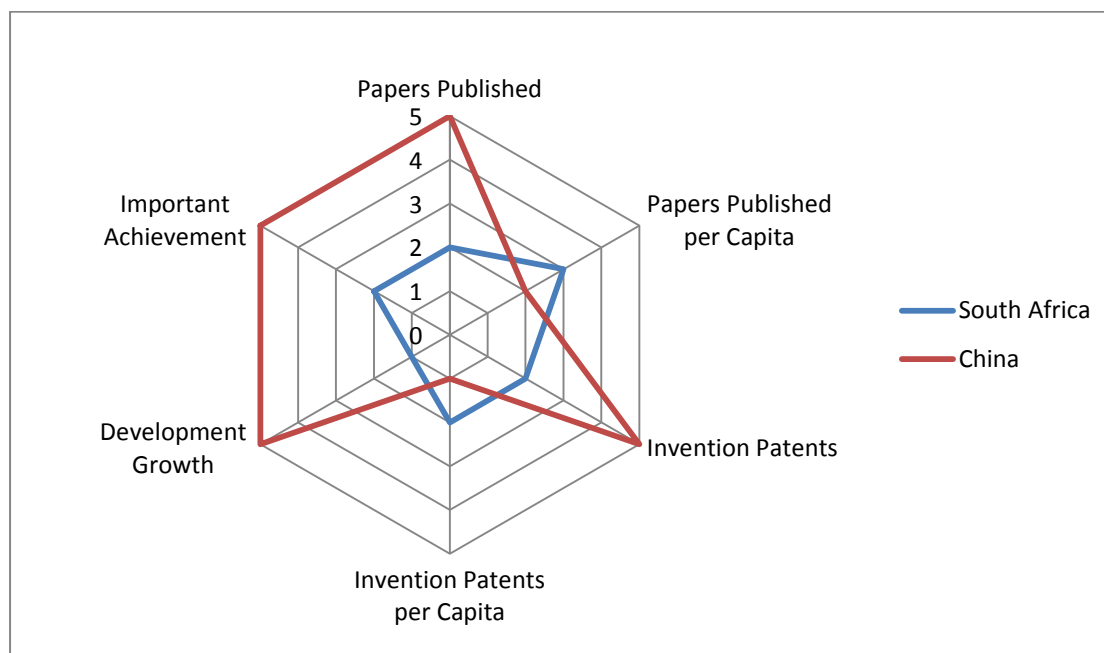
## Science and Technology Development

South Africa is a middle-income country with an abundant supply of resources and well-developed financial, legal, communications, energy, and transport sectors. The technology development of South Africa is mainly achieved in mining and the energy fields.

China is a country which aims to build a high-technology nation, science and technology development in China has grown rapidly. In the early 21st century, as commonly admitted, the gap in high-technology research and development between China and the world's advanced countries has shrunk; 60 per cent of technologies, including atomic energy, space,

high-energy physics, biology, computer and information technology have reached or are close to the world advanced level (Science and technology in the People's Republic of China).

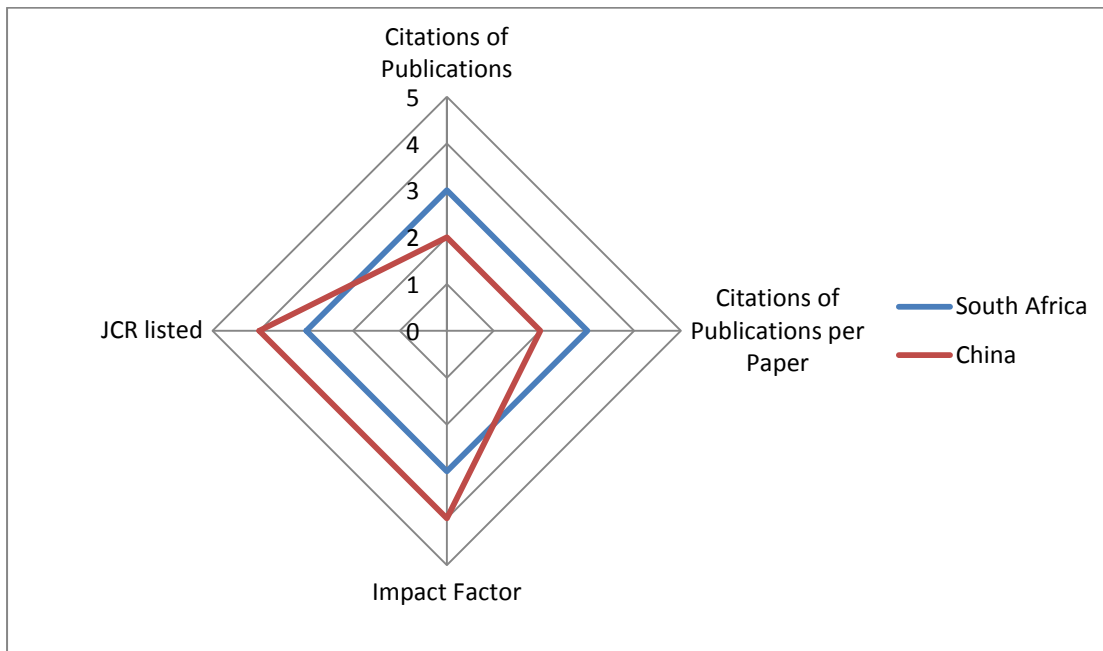
Aspects	South Africa	China	Note
Papers Published	Poor	Excellent	China had 184,080 in 2008 and 18,466 publications generated by South African researchers.
Papers Published per Capita	Moderate	Poor	0.38 publications per 1000 people in South Africa and 0.14 publications per 1000 people in China.
Invention Patents	Poor	Excellent	South Africa had 7740 patents granted in 2008, China had 93,706 invention patents granted in 2008 and ranked second in the world.
Invention Patents per Capita	Poor	Very Bad	0.15 patents per 1000 people for South Africa and 0.07 patents per 1000 people in China.
Development Growth	Very Bad	Excellent	South Africa gained 7205 patents in 2007 and had 7740 patents granted in 2008, an increase of 7.4%. China's published academic papers surged more than seven-fold to 184,080 in 12 years. From 2007-2008, the growth rate of China's overseas patent filings in Europe, Japan and the U.S. were 33.5%, 15.9% and 14.1%, respectively.
Important Achievement	Poor	Excellent	China invented or innovated Manned spacecraft, 4th generation fighter aircraft, and High-speed railways, Maglev wind power generators, Synthesis of crystalline bovine insulin, TianHe interconnect supercomputing etc. Important competitive invention in South Africa has been rare in the 21st century.
Overall	Poor	Good	
Science and Technology Development	Weakness	Strength	



### Paper Citation and Impact Factor

This section referenced ISI Essential Science Indicators indicates the paper citation and impact factor of South African and Chinese S&T output through the journals.

Aspects	South Africa	China	Note
Citations of Publications	Moderate	Poor	South African authors have earned an average of 5.2 citations per publication in the last 30 years. Citations of Chinese journals covered by the Science Citation Index were 0.326 in 1999. The total amount ranked No.8 in the world in last 10 years.
Citations of Publications per Paper	Moderate	Poor	South Africa has an average of 4.91 citations of publications per paper, and China has 3.86 citations of publications per paper
Impact Factor	Moderate	Good	South Africa had an impact factor of 0.506 in 2009 and China had 0.957 ranking 8 <sup>th</sup> in the same year.
Journals listed on JCR	Moderate	Good	South Africa has 33 journals in JCR and China has 137 journals. Compared to the USA;s 2697 and Finland's 14 journals.
<b>Overall</b>	<b>Moderate</b>	<b>Moderate</b>	
<b>Science and Technology Development</b>	<b>Opportunity</b>	<b>Strength</b>	



## Intellectual Property Protection

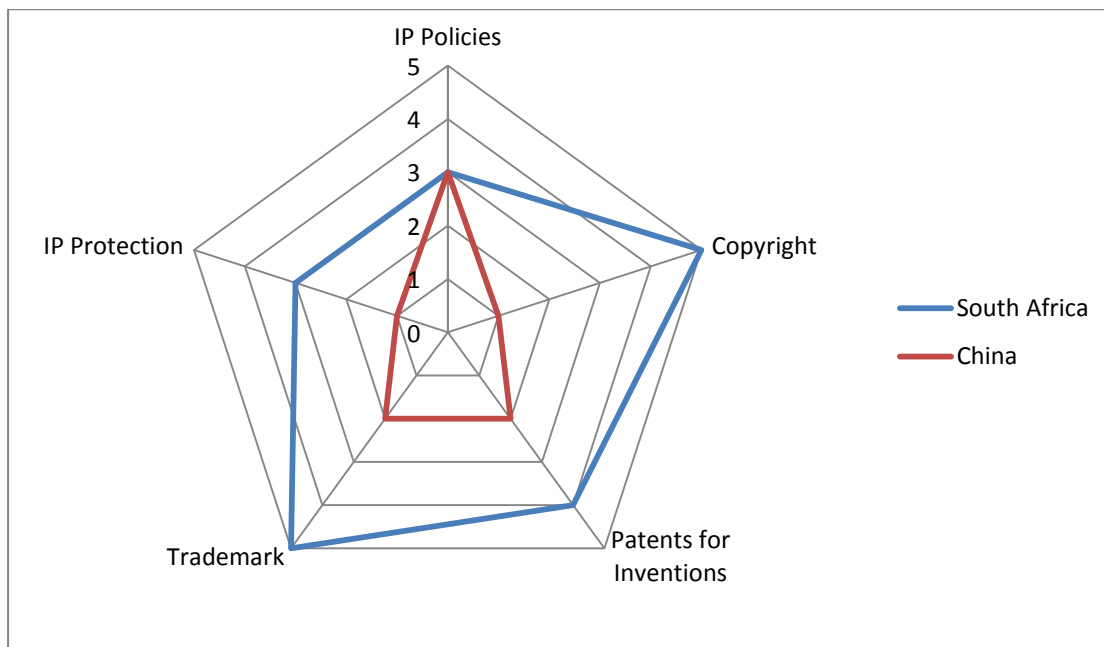
There are not many publications to evaluate how the protection is working in South African society. The limited existing documents cannot categorically prove that IP protection is doing well, but actual evidence indicates that existing policies and laws are driving IP protection to provide a fair and healthy competitive environment for firms.

The protection of IP is a fatal weakness in the Chinese innovation system. Failure to protect intellectual property rights in the Chinese market leading to massive theft and piracy is constantly in the background.

Aspects	South Africa	China	Note
IP Policies	Moderate	Moderate	South Africa has implemented regulation of the Copyright Act since 1978. Since The Patent Law was launched in 1985 intellectual property rights have developed vibrantly in China.
Copyright	Excellent	Very Bad	Copyright Protection aims to offer proof of the existence of a specific file, script, design, music or literary work at a specific time and date. Chinese companies and underground organisations pirate goods at an alarming rate. This activity has been quoted by Microsoft's CEO as "sky high."
Patents for Invention	Good	Poor	South African criteria for originality of an invention are similar to those of most of the First World, such as Europe, USA and



Aspects	South Africa	China	Note
			Australia. Selecting a trusted partner in China with authentic IP practices and a secure infrastructure is a practical means of protecting IP
Trade mark	Excellent	Poor	While common law rights are acquired through use of a trade mark, the advantages of registration are substantial in South Africa. Chinese trade mark is not strictly established or productive enough to provide a healthy competitive environment for enterprises.
IP Protection	Good	Very Bad	It would thus appear that South African intellectual property laws are its 'best practice' and able to accommodate specific developing country concerns. 79% of computer users in China use pirated software against South Africa's 35%, ranking China 27th in the world in 2009.
<b>Overall</b>	<b>Good</b>	<b>Very Bad</b>	
<b>Intellectual Property Right Protection</b>	<b>Strength &amp; Opportunity</b>	<b>Weakness</b>	



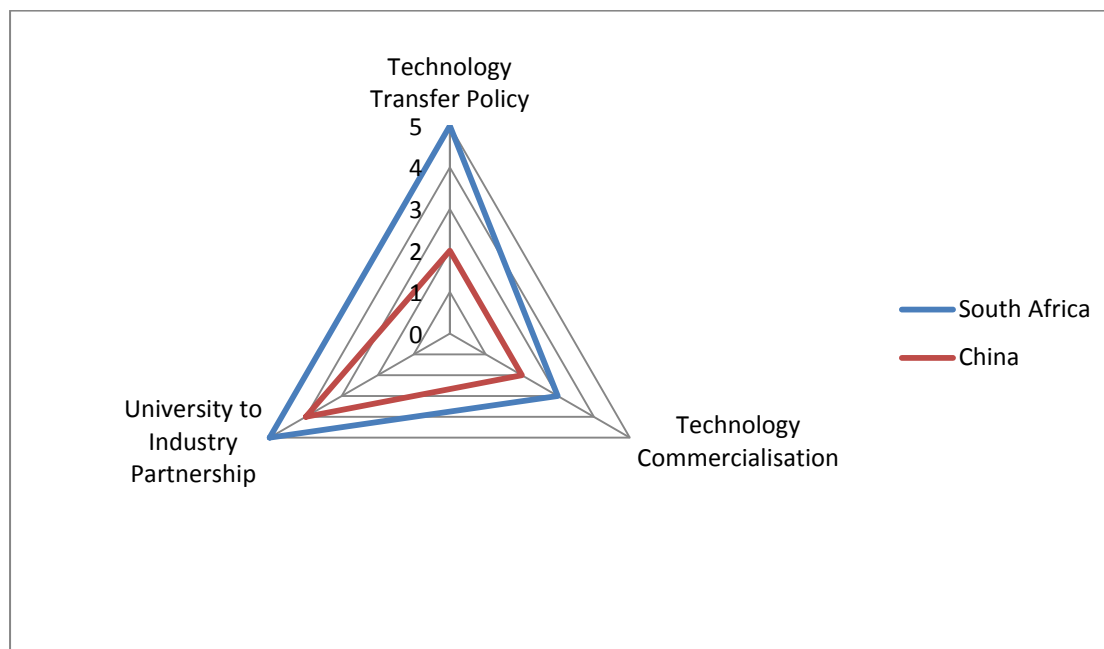
## Technology Transfer

Technology transfer or knowledge transfer sometimes is a key procedure in an entire innovation process. Any single brilliant innovative idea without successful commercialisation means nothing to the entire National Innovation System.

During studies of the Chinese innovation system, the question as to why the S&T level is high although low-cost or low-tech product manufacturing and exporting are flourishing should be asked. China may need to pay more attention to technology transfer, and simultaneously, government should play the key role in correcting the problem that emphasises S&T capability without lack of attention on commercialisation.

Aspects	South Africa	China	Note
Technology Transfer Policy	Excellent	Poor	South Africa has made government support for research and innovation a key part of the national economic-development strategy. The Chinese government prefers to encourage indigenous enterprise innovation. On the other hand, the Chinese government allows and encourages local companies to collaborate with universities or foreign technological companies, but China has no government policies or investment in this field at present.
Technology Commercialisation	Moderate	Poor	The SARIMA was formed in 2002 in SA to assume the lead role in national efforts to build capability in research and innovation. The increase in total shares in high-tech imports rose from 16.3% in 1995 to 34% in 2008. The export of high-tech products, around 415.6 billion US Dollars in 2008, shares 29.1% of total exports. For China, refer to the TT Policies aspect.
University to Industry Partnership	Excellent	Good	The Technology Stations Programme of South Africa is designed to strengthen and accelerate the interactions between Universities and SMMEs. China's technology bridging system has progressed rapidly recently, but still lags that of developed countries and is unable to satisfy the needs of the other actors in its NIS.
<b>Overall</b>	<b>Good</b>	<b>Moderate</b>	

Aspects	South Africa	China	Note
Technology Transfer	Strength	Weakness & Opportunity	



### National Research Institutes

Enormous differences in National Research Institutes exist between South Africa and China. The institutes owned by the South African government are leaders of each area. They have researching functions, but leadership plays the more important role. Although they do not participate in many S&T missions, National Research Institutes have a distinct scientific function and play an active leadership role in the NIS of South Africa.

On the other hand, Chinese National Research Institutes control most of the S&T development missions. They are lead directly by the central government. The over 4600 research institutes are powerful tools of the Chinese central government and for the country’s innovation development.

Aspects	South Africa	China	Note
Overall	Moderate	Excellent	The National Research Foundation (NRF) manages 7 South African national research facilities. There were 4,690 research institutes affiliated to administrative bodies higher than the “country” level

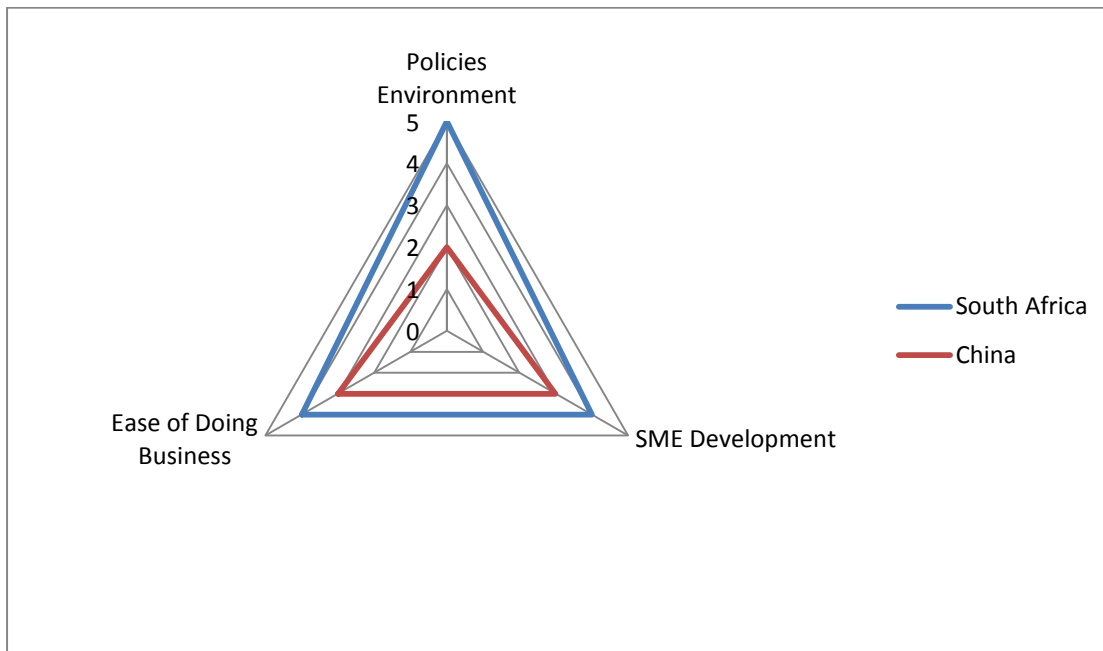
Aspects	South Africa	China	Note
National Research Institutes	Strength	Strength	

A Star diagram is not applicable for the role of National Research Institutes.

### Small and Medium Enterprises

SMEs are playing an important role in South Africa. The statistics show that the larger the GDP of a province, the higher the number of SMEs in South Africa. This fact supports the notion that Small and Medium Enterprises require collective efficiency, external economies and the benefit of economic agglomeration.

Aspect	South Africa	China	Note
Policies Environment	Excellent	Poor	South Africa has many policies to help SME growth. Besides the country-wide policies, provinces also have their own policies to support SMEs. The Chinese government's financial support to SMEs provides mainly special funds for investment and investment in industrial policy, but to date there is only one bank which mainly supports SMEs.
SME Development	Good	Moderate	South Africa ranked 35th out of 178 countries in the World Bank and International Finance Corporation's Doing Business 2008 report and China ranked 83.
Ease of Doing Business	Good	Moderate	South Africa ranked 34 and China 79 out of 183 countries.
Average Credit	Good	Moderate	
Government Leadership	Strength	Weakness & Opportunity	



## International Cooperation

Most of the world's countries are dependent on each other for their macro-economic health. The seriously unbalanced trading business would attack the economy causing deformity.

The problem in South Africa is that the country is too dependent on exports, particularly of natural resources, although it has to be fully understood that it is the development model of the country. So far, South Africa is very much involved in global development and contributing to the world economy. South Africa's involvement in BRICS provides very strong evidence. China started opening the door in 1979 and became a WTO member in 1995. Nowadays it is called the "World Factory". The difference between South Africa and China is that China is an exporting surplus country, which means that China is also very much dependent on the world economy, but vice versa. Both countries as the most important developing countries are driving the world development dynamic not only in economy, but also in science and technology spheres.

Aspect	South Africa	China	Note
Business Globalisation	Good	Excellent	South Africa has developed strong relations with markets in the rest of Africa, Asia and Latin America. China, the largest exporting country and the second largest importer, is not only well involved in the international market, but is

Aspect	South Africa	China	Note
			also playing a very important role in the world economic growth.
R&D collaboration	Good	Good	South African criteria for originality of an invention are analogous to those of most of the First World. China has cooperated through programmes in science and technology with 152 countries and regions.
Overall	Good	Good	
International Cooperation	Strength and Opportunity	Strength and Opportunity	

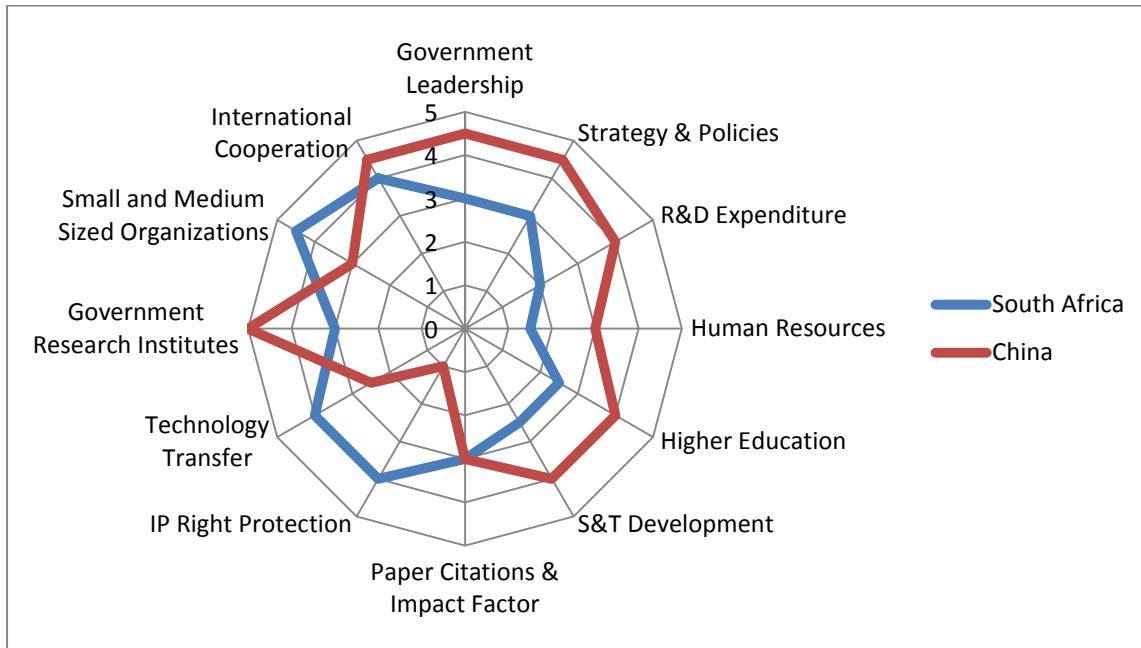
A Star diagram is not applicable for the role of National Research Institutes.

### Other factors

Besides the aspects above, there are other factors influencing the NIS system of each country directly or potentially. Those factors are not always considered as criteria while researchers study NIS, but for the specific countries, specific problems would have an influence on the NIS.

Other Aspects	South Africa	China
Strengths		
Weaknesses	HIV/AIDS, Poverty	
Opportunities	Poor Population	
Threats	Crime, Corruption, Gap between rich and poor, Poverty and Public Health	Corruption, Population and Ageing Population

## Summary



## Collaborative Opportunities

According to the SWOT analysis, opportunities between South Africa and China are shown. Bases on the different political systems, the governments might play different roles in each country's NIS; policy-making is one of the areas which could strengthen cooperation. For example, the Silicon Valley model is a successful example of S&T development and technology transfer, which indicates that both South Africa and China have good universities and scientific and technological grounding. China has rich experiences of setting special economic zones which could help South Africa to boost the economy and solve the bad employment situation.

South Africa and China both have an extreme brain-drain problem. Educational communication would bring opportunities for personnel interactions, improve academic exchange and enhance understanding for both countries.

China's development in science and technology has risen dramatically during the last decades, especially in aviation, information and the communication domain. On the other hand, South Africa has the best basic industry, military and agricultural technology. Tremendous opportunity and common interests exist in this area. South Africa and China should build bilateral relations of mutual benefit.

## Conclusion

### *South Africa*

The study recognises that the South African innovation system remains fragmented and that the country is becoming less competitive. Lack of highly-skilled human resources and high attrition rates is a critical problem which limits the stability of economic development.

Nevertheless, there are also many opportunities for South Africa as an important country in Africa. South Africa has a variety of the best resources in Sub-Saharan Africa and an increasingly demand for science and technology.

The OECD Report reviews of Innovation Policy: South Africa mentioned that South African innovation system needs to strengthen the mechanisms for integration across, or changing the current organisational location of, key interdepartmental interfaces concerned with funding research in the higher education sector, providing innovation-related and other support for enterprises, and fostering high-level human resource development through enterprise. (OECD, 2007)

To alleviate the human resource problems, the OECD report also suggests that South Africa needs to seek modification of the current immigration policy, going beyond steps that merely reduce difficulties for incoming highly skilled people, and instead develop a more pro-active “green card” type of scheme that is at least as attractive to international scientific, technological and other talent as similar schemes in other countries. (OECD, 2007)

### *China*

The SWOT analysis presented that the Chinese NIS has characteristics of a high concentration of resources. The government as the central role player in the NIS provided high, efficient and reasonable distribution to the downstream of the system. However, it also brings a systemic threat in which the self-regulation capability is weaker than normal. It means if the central resource distribution has a problem or has made a mistake, it would not only influence a part of NIS, an unbalanced problem would attack the NIS and the entire economy.

An exception is the Intellectual Property Protection in China that government leaves to develop freely and is one of the aspects in which the government should play a stringent regulation role. The fact is that China has lost control and piracy products have formed an industry which makes the situation even more complicated. This complication means that the situation should be changed before it gets even worse, and not laissez faire.



Generally, China seems to be doing better than South Africa, but China is also facing fatal problems in some fields. The failure of IP protection is one of the most dangerous threats for the NIS.

## **Validation Method**

Each expert was given a questionnaire to fill out. The questionnaire was filled out as the questions and research were discussed. These questions were proposed according to the research questions.

The interviewees are required to answer and evaluate the aspects relevant to their own background or fields of experience on a scale of 1~5, with 5 being 'strongly agree' and 1 being 'strongly disagree'. Should they not have an idea about the question, they should write "unknown".

# **Appendix II**

## **Validation Feedback**

**Mr Bernard LorioI**

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
Q1	Criteria	To what extent do you agree that the criteria I used in the thesis covered all factors about a country's NIS? Does it answer research question 1?	4	I think there is another thing you should fit in as a criterion that is the government's vision. Chinese government look very long term, but South African government only care of now. Very short. I think to this factor has very important influence.
Q2	Government Leadership	To what extent do you agree that government should play a core role by initiating strategies and policies in NIS?	5	
Q3		To what extent do you agree that the oversight by government is important to control the NIS?	5	
Q4		To what extent would you agree that national R&D programmes and plans are the dynamics for NIS?	5	
Q5	Strategy & Policies	To what extent do you agree that a bundle of good strategies are important to the future development of NIS?	5	
Q6		To what extent do you agree on the comparison of Chinese strategies and policies which are more focused on the international status, whereupon, South African strategies are more down to earth and concentrate on employment and	5	

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
		national economy?		
Q7		To what extent do you agree about the verdict which was made about the implementation of policies in your residential region?	5	
Q8	R&D Expenditure	To what extent do you agree that gross R&D expenditure is a scale for NIS activity?	5	
Q9		To what extent do you agree that percentage expenditure of GDP shows how important NIS is in a country's strategy?	5	
Q10		To what extent do you agree that foreign investment figures show the attractiveness of a country to the NIS?	5	
Q11	Human Resources	To what extent do you agree that FTE R&D Personnel statistics show how the relative activeness of the S&T development contributes to a country? What about the per capita?	5	
Q12		To what extent do you agree that the brain-drain problem is a serious problem happening in both countries and proposes a big threat for NIS?	5	

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
Q13		To what extent do you agree that South Africa has very low attraction for personnel, or could we say that South Africa fails us in that aspect?	3	You are right. But you didn't count natural environment maybe? If you think about that, many people would like to stay in SA, rather than China, although air quality in Beijing is much better than 5 years ago.
Q14	Higher Education	To what extent do you agree that South Africa needs more universities?	2	South Africa needs to increase the basic education widely before they establish more universities.
Q15		To what extent do you agree that the enormous growth in higher education enrolment and graduation helps to show growth in delivering personnel to improve NIS?	3	I think it's more about quality than quantity.
Q16		To what extent do you agree that both South Africa and China have the ability to establish the world class universities which they need?	5	
Q17	S&T Development	According to the study, to what extent do you agree that South Africa S&T development is sluggish?	4	I think there is still something going on.
Q18		To what extent do you agree that the population influences the S&T development in China?	3	The power of S&T development has to do with a nation not people.
Q19		To what extent do you agree that in the S&T sphere South Africa should cooperate with China?	5	
Q20	Paper Citation & Impact	To what extent do you agree that paper citations	5	

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
	Factor	relatively show the R&D level of South Africa and China?		
Q21		To what extent do you agree that the impact factors illustrate the essence of current R&D development?	5	
Q22		To what extent do you agree that language barriers restrict the impact factor of China?	5	
Q23	IP Right Protection	To what extent do you agree that South Africa has well developed laws in place to protect IP right?	5	
Q24		To what extent do you agree that IP protection is the biggest threat for China in the NIS?	5	
Q25		To what extent do you agree that Chinese trade mark protection is not as bad as other IP protection, especially the protection of famous trade marks, but still it is recognised in South Africa as a failure?	5	
Q26	Technology Transfer	To what extent do you agree that South Africa has made government support for research and innovation a key part of the national economic-development strategy?	5	
Q27		To what extent do you agree that TT productivity is very low in China?	5	
Q28		To what extent do you agree that there is big potential should South	5	

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
		Africa and China cooperate?		
Q29	Government Research Institutes	To what extent do you agree that government research institutes should play the main role on S&T development in a NIS?	4	South African GRIs have budget constraint.
Q30		To what extent do you agree that South Africa makes GRIs more productive?	5	
Q31	Small and Medium Sized Organisations	To what extent do you agree that as the dynamics of economic growth, SMEs have not developed well in South Africa and China?	5	
Q32		To what extent do you agree that South Africa has good policies to encourage SMEs?	1	I don't agree with it. China is easier to do business than America. I would be easier than SA as well.
Q33		To what extent do you agree that the BEE policy is a threat to the SMEs in South Africa?	4	There is something good in BEE policy.
Q34	International Cooperation	To what extent do you agree that South Africa and China are both well involved in globalisation?	3	No, I don't agree. The raw material market of South Africa is good. But many aspects cannot compare with China.
Q35		To what extent do you agree that South Africa has more regional cooperation, but China is more internationalized with it?	5	
Q36	Other Factors	To what extent do you agree that crimes, HIV/AIDS, poverty are badly influencing the NIS in South Africa?	5	

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
Q37		To what extent do you agree that South Africa and China have the same problems of corruption that hinder the NIS development?	5	
Q38		To what extent do you agree that population is a threat to affect the Chinese NIS?	5	
Q39		To what extent do you agree that South Africa and China have opportunities to collaborate in S&T, Technology Transfer, IP protection and international cooperation fields? Does it answer research question 4?	3	Culture and way of communication are very different. You should have a look at how to solve this problem.



**Mr Cecil Ramonotsi**

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
Q1	Criteria	To what extent do you agree that the criteria I used in the thesis covered all factors about a country's NIS? Does it answer research question 1?	3	Refer to my comments on e-mail and word document
Q2	Government Leadership	To what extent do you agree that government should play a core role by initiating strategies and policies in NIS?	4	
Q3		To what extent do you agree that the oversight by government is important to control the NIS?	4	
Q4		To what extent would you agree that national R&D programmes and plans are the dynamics for NIS?	4	
Q5	Strategy & Policies	To what extent do you agree that a bundle of good strategies are important to the future development of NIS?	4	
Q6		To what extent do you agree on the comparison of Chinese strategies and policies which are more focused on the international status, whereupon, South African strategies are more down to earth and concentrate on employment and national economy?	2	Literature states that SA NIS system is designed to be more Macro environment user friendly as opposed localisation.

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
Q7		To what extent do you agree about the verdict which was made about the implementation of policies in your residential region?	3	There was a public participation on the latest gazetted bills on Innovation and IP (IPR bill and TIA bill).It may have needed or been allowed more time for the audience to comment and critique.
Q8	R&D Expenditure	To what extent do you agree that gross R&D expenditure is a scale for NIS activity?	4	
Q9		To what extent do you agree that percentage expenditure of GDP shows how important NIS is in a country's strategy?	4	
Q10		To what extent do you agree that foreign investment figures show the attractiveness of a country to the NIS?	4	
Q11	Human Resources	To what extent do you agree that FTE R&D Personnel statistics show how the relative activeness of the S&T development contribute to a country? What about the per capita?	4	Per Capita measurements are more reliable
Q12		To what extent do you agree that the brain-drain problem is a serious problem happening in both countries and proposes a big threat for NIS?	4	
Q13		To what extent do you agree that South Africa has very low attraction for personnel, or could we say that South Africa fails us in	3	not completely so, Dept of Home Affairs - migration and labour policies are currently being revamped

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
		that aspect?		
Q14	Higher Education	To what extent do you agree that South Africa needs more universities?	4	Education system pipelining in the value chain, re-aligning the Foundation phase at school level remains a challenge. Yes, we need more universities, but quality of education at school level must be enhanced before we talk of numbers to be pipelined to universities.
Q15		To what extent do you agree that the enormous growth in higher education enrolment and graduation helps to show growth in delivering personnel to improve NIS?	4	
Q16		To what extent do you agree that both South Africa and China have the ability to establish the world class universities which they need?	4	
Q17	S&T Development	According to the study, to what extent do you agree that South Africa S&T development is sluggish?	3	
Q18		To what extent do you agree that the population influences the S&T development in China?	2	Culture would strongly do so.
Q19		To what extent do you agree that in the S&T sphere South Africa should cooperate with China?	4	

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
Q20	Paper Citation & Impact Factor	To what extent do you agree that paper citations relatively show the R&D level of South Africa and China?	3	It actually shows the probability of succesful R&D
Q21		To what extent do you agree that the impact factors illustrate the essence of current R&D development?	4	
Q22		To what extent do you agree that language barriers restrict the impact factor of China?	3	
Q23	IP Right Protection	To what extent do you agree that South Africa has well developed laws in place to protect IP right?	4	
Q24		To what extent do you agree that IP protection is the biggest threat for China in the NIS?	4	
Q25		To what extent do you agree that Chinese trade mark protection is not as bad as other IP protection, especially the protection of famous trade marks, but still it is recognised in South Africa as a failure?	3	
Q26	Technology Transfer	To what extent do you agree that South Africa has made government support for research and innovation a key part of the national economic-development strategy?	3	
Q27		To what extent do you agree that TT productivity is very low in China?	2	Refer to my comments on e-mail and word document

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
Q28		To what extent do you agree that there is big potential should South Africa and China cooperate?	4	
Q29	Government Research Institutes	To what extent do you agree that government research institutes should play the main role on S&T development in a NIS?	4	
Q30		To what extent do you agree that South Africa makes GRIs more productive?	4	
Q31	Small and Medium Sized Organisations	To what extent do you agree that as the dynamics of economic growth, SMEs have not developed well in South Africa and China?	4	
Q32		To what extent do you agree that South Africa has good policies to encourage SMEs?	4	
Q33		To what extent do you agree that the BEE policy is a threat to the SMEs in South Africa?	2	Refer to my comments on e-mail and word document
Q34	International Cooperation	To what extent do you agree that South Africa and China are both well involved in globalisation?	4	
Q35		To what extent do you agree that South Africa has more regional cooperation, but China is more internationalized with it?	2	BRICS-SA collaboration shows that SA is in global space
Q36	Other Factors	To what extent do you agree that crimes, HIV/AIDS, poverty are badly influencing the NIS in South Africa?	3	Yes, in medium to long term

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
Q37		To what extent do you agree that South Africa and China have the same problems of corruption that hinder the NIS development?	2	I have not seen any correlation to this effect. However, I have picked up supply chain challenges in the literature that I have come through to date. These challenges are not relating to governance but are referring to impedments on facilitating technology transfer among and between firms and institutions of higher learning.
Q38		To what extent do you agree that population is a threat to affect the Chinese NIS?	2	In fact it is a strength, it offers a competitive advantage or temporary advantage in sense that strategies to compete change every minute or seconds in business circles.
Q39		To what extent do you agree that South Africa and China have opportunities to collaborate in S&T, Technology Transfer, IP protection and international cooperation fields? Does it answer research question 4?	3	Yes, it answers research Q4 partly, there are many more factors that can influence that.

**Mr David Gong**

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
Q1	Criteria	To what extent do you agree that the criteria I used in the thesis covered all factors about a country's NIS? Does it answer research question 1?	5	Yes, I agree. You have answered.
Q2	Government Leadership	To what extent do you agree that government should play a core role by initiating strategies and policies in NIS?		I don't know!
Q3		To what extent do you agree that the oversight by government is important to control the NIS?		I don't know!
Q4		To what extent would you agree that national R&D programmes and plans are the dynamics for NIS?		I don't know!
Q5	Strategy & Policies	To what extent do you agree that a bundle of good strategies are important to the future development of NIS?	5	We can see the S&T encouragement policies are working in China. Your father's company is one of the beneficiaries.
Q6		To what extent do you agree on the comparison of Chinese strategies and policies which are more focused on the international status, whereupon, South African strategies are more down to earth and concentrate on employment and national economy?	5	I agree with Chinese part.
Q7		To what extent do you agree about the verdict which was made about the implementation of policies in your residential region?	4	China has many great policies and good policy environment. But implementing them, the various regions vary.

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
Q8	R&D Expenditure	To what extent do you agree that gross R&D expenditure is a scale for NIS activity?		I don't know!
Q9		To what extent do you agree that percentage expenditure of GDP shows how important NIS is in a country's strategy?	4	Can I just say Obviously?
Q10		To what extent do you agree that foreign investment figures show the attractiveness of a country to the NIS?	3	I think that relative to technology transfer. It evaluates how simply and cheap their technologies could become products in the country.
Q11	Human Resources	To what extent do you agree that FTE R&D Personnel statistics show how the relative activeness of the S&T development contributes to a country? What about the per capita?		I don't know!
Q12		To what extent do you agree that the brain-drain problem is a serious problem happening in both countries and proposes a big threat for NIS?	5	I believe so. But I am back to China, and I think you are coming back too.
Q13		To what extent do you agree that South Africa has very low attraction for personnel, or could we say that South Africa fails us in that aspect?		I don't know!
Q14	Higher Education	To what extent do you agree that South Africa needs more universities?		I don't know!
Q15		To what extent do you agree that the enormous growth in higher education		I don't know!



	Aspects	Questions	Scales 1~5 or Unknown	Motivation
		enrolment and graduation helps to show growth in delivering personnel to improve NIS?		
Q16		To what extent do you agree that both South Africa and China have the ability to establish the world class universities which they need?		I don't know!
Q17	S&T Development	According to the study, to what extent do you agree that South Africa S&T development is sluggish?		I don't know!
Q18		To what extent do you agree that the population influences the S&T development in China?		I don't know!
Q19		To what extent do you agree that in the S&T sphere South Africa should cooperate with China?		I don't know!
Q20	Paper Citation & Impact Factor	To what extent do you agree that paper citations relatively show the R&D level of South Africa and China?		I don't know!
Q21		To what extent do you agree that the impact factors illustrate the essence of current R&D development?		I don't know!
Q22		To what extent do you agree that language barriers restrict the impact factor of China?	5	I was a researcher. So I can say that many Chinese publications were really valuable. So shame they cannot be shared with the rest of world.
Q23	IP Right Protection	To what extent do you agree that South Africa has		I don't know!

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
		well developed laws in place to protect IP right?		
Q24		To what extent do you agree that IP protection is the biggest threat for China in the NIS?	5	Can't agree more. You know everything about what happened to Tensar in China.
Q25		To what extent do you agree that Chinese trade mark protection is not as bad as other IP protection, especially the protection of famous trade marks, but still it is recognised in South Africa as a failure?	5	I cannot agree that our trade mark protection is better than others. As for Tensar, I think you also know that, there are company trying to copy our name and trade marks. The truth is, we cannot do anything about it.
Q26	Technology Transfer	To what extent do you agree that South Africa has made government support for research and innovation a key part of the national economic-development strategy?		I don't know!
Q27		To what extent do you agree that TT productivity is very low in China?	3	I can only say China is different. Some of them are doing really well, some parts not quite so.
Q28		To what extent do you agree that there is big potential should South Africa and China cooperate?		I don't know!
Q29	Government Research Institutes	To what extent do you agree that government research institutes should play the main role on S&T development in a NIS?		I don't know!
Q30		To what extent do you agree that South Africa makes GRIs more productive?		I don't know!

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
Q31	Small and Medium Sized Organisations	To what extent do you agree that as the dynamics of economic growth, SMEs have not developed well in South Africa and China?	4	I heard about there is a new policy in China is to encourage SMEs development session. Maybe you should find out.
Q32		To what extent do you agree that South Africa has good policies to encourage SMEs?		I don't know!
Q33		To what extent do you agree that the BEE policy is a threat to the SMEs in South Africa?		I don't know!
Q34	International Cooperation	To what extent do you agree that South Africa and China are both well involved in globalisation?	5	Agree, BRICS proved.
Q35		To what extent do you agree that South Africa has more regional cooperation, but China is more internationalized with it?	4	South Africa has little influence to New Zealand economy, as far as I know. But on the other hand, China is supplying basically everything.
Q36	Other Factors	To what extent do you agree that crimes, HIV/AIDS, poverty are badly influencing the NIS in South Africa?	4	I'm not sure about that, but with common knowledge, it should be right. So I give 4
Q37		To what extent do you agree that South Africa and China have the same problems of corruption that hinder the NIS development?	5	Due to corruption and local protectionism, promoting our new technology has great resistance in China.
Q38		To what extent do you agree that population is a threat to affect the Chinese NIS?	2	Maybe it gives bad numbers on average, but the ability of innovation doesn't base on the every single person's work for a country, I

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
				think.
Q39		To what extent do you agree that South Africa and China have opportunities to collaborate in S&T, Technology Transfer, IP protection and international cooperation fields? Does it answer research question 4?	4	As you mentioned in the review, there is always more things impact of NIS directly or potentially. But I think you are done well.
			4.28	Isn't it great?

**Mr Jin Cheng**

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
Q1	Criteria	To what extent do you agree that the criteria I used in the thesis covered all factors about a country's NIS? Does it answer research question 1?	4	
Q2	Government Leadership	To what extent do you agree that government should play a core role by initiating strategies and policies in NIS?	5	
Q3		To what extent do you agree that the oversight by government is important to control the NIS?	5	
Q4		To what extent would you agree that national R&D programmes and plans are the dynamics for NIS?	5	
Q5	Strategy & Policies	To what extent do you agree that a bundle of good strategies are important to the future development of NIS.	3	An appropriate example could help me to understand better
Q6		To what extent do you agree on the comparison of Chinese strategies and policies which are more focused on the international status, whereupon, South African strategies are more down to earth and concentrate on employment and national economy?	4	China cares of both.
Q7		To what extent do you agree about the verdict which was made about the implementation of policies in your residential region?	4	
Q8	R&D Expenditure	To what extent do you agree that gross R&D expenditure is a scale for NIS activity?	3	Cost cannot measure the contribution to the innovation of NIS properly

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
Q9		To what extent do you agree that percentage expenditure of GDP shows how important NIS is in a country's strategy?	4	
Q10		To what extent do you agree that foreign investment figures show the attractiveness of a country to the NIS?	5	
Q11	Human Resources	To what extent do you agree that FTE R&D Personnel statistics show how the relative activeness of the S&T development contributes to a country? What about the per capita?	-	
Q12		To what extent do you agree that the brain-drain problem is a serious problem happening in both countries and proposes a big threat for NIS?	4	
Q13		To what extent do you agree that South Africa has very low attraction for personnel, or could we say that South Africa fails us in that aspect?	-	
Q14	Higher Education	To what extent do you agree that South Africa needs more universities?	3	quantity is not exactly equal to quality
Q15		To what extent do you agree that the enormous growth in higher education enrolment and graduation helps to show growth in delivering personnel to improve NIS?	4	
Q16		To what extent do you agree that both South Africa and China have the ability to establish the world class universities which they need?	5	
Q17	S&T Development	According to the study, to what extent do you agree that South	-	

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
		Africa S&T development is sluggish?		
Q18		To what extent do you agree that the population influences the S&T development in China?	-	
Q19		To what extent do you agree that in the S&T sphere South Africa should cooperate with China?	5	
Q20	Paper Citation & Impact Factor	To what extent do you agree that paper citations relatively show the R&D level of South Africa and China?	5	
Q21		To what extent do you agree that the impact factors illustrate the essence of current R&D development?	-	
Q22		To what extent do you agree that language barriers restrict the impact factor of China?	-	
Q23	IP Right Protection	To what extent do you agree that South Africa has well developed laws in place to protect IP right?	5	
Q24		To what extent do you agree that IP protection is the biggest threat for China in the NIS?	5	
Q25		To what extent do you agree that Chinese trade mark protection is not as bad as other IP protection, especially the protection of famous trade marks, but still it is recognised in South Africa as a failure?	4	Trade mark Law is fragment in China. Most serious problem it is difficult to win the case on the court and get paid.
Q26	Technology Transfer	To what extent do you agree that South Africa has made government support for research and innovation a key part of the national economic-development strategy?	5	

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
Q27		To what extent do you agree that TT productivity is very low in China?	3	There are good spheres.
Q28		To what extent do you agree that there is big potential should South Africa and China cooperate?	-	
Q29	Government Research Institutes	To what extent do you agree that government research institutes should play the main role on S&T development in a NIS?	-	
Q30		To what extent do you agree that South Africa makes GRIs more productive?	-	
Q31	Small and Medium Sized Organisations	To what extent do you agree that as the dynamics of economic growth, SMEs have not developed well in South Africa and China?	5	
Q32		To what extent do you agree that South Africa has good policies to encourage SMEs?	5	
Q33		To what extent do you agree that the BEE policy is a threat to the SMEs in South Africa?	5	
Q34	International Cooperation	To what extent do you agree that South Africa and China are both well involved in globalisation?	5	
Q35		To what extent do you agree that South Africa has more regional cooperation, but China is more internationalized with it?	-	
Q36	Other Factors	To what extent do you agree that crimes, HIV/AIDS, poverty are badly influencing the NIS in South Africa?	5	



	Aspects	Questions	Scales 1~5 or Unknown	Motivation
Q37		To what extent do you agree that South Africa and China have the same problems of corruption that hinder the NIS development?	5	
Q38		To what extent do you agree that population is a threat to affect the Chinese NIS?	3	Population brings big market and opportunities to Chinese economic growth.
Q39		To what extent do you agree that South Africa and China have opportunities to collaborate in S&T, Technology Transfer, IP protection and international cooperation fields? Does it answer research question 4?	5	

**Dr. Louis Louw**

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
Q1	Criteria	To what extent do you agree that the criteria I used in the thesis covered all factors about a country's NIS? Does it answer research question 1?	3	I think that there are some missing indicators of the knowledge flows within National Innovation systems, such as industry alliances, university/ industry interactions, personnel mobility etc. I realise these are however very difficult to measure.
Q2	Government Leadership	To what extent do you agree that government should play a core role by initiating strategies and policies in NIS?	5	
Q3		To what extent do you agree that the oversight by government is important to control the NIS?	5	
Q4		To what extent would you agree that national R&D programmes and plans are the dynamics for NIS?	4	
Q5	Strategy & Policies	To what extent do you agree that a bundle of good strategies are important to the future development of NIS.	5	
Q6		To what extent do you agree on the comparison of Chinese strategies and policies which are more focused on the international status, whereupon, South African strategies are more down to earth and concentrate on employment and national economy?	unknown	

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
Q7		To what extent do you agree about the verdict which was made about the implementation of policies in your residential region?	3	
Q8	R&D Expenditure	To what extent do you agree that gross R&D expenditure is a scale for NIS activity?	4	
Q9		To what extent do you agree that percentage expenditure of GDP shows how important NIS is in a country's strategy?	4	
Q10		To what extent do you agree that foreign investment figures show the attractiveness of a country to the NIS?	5	
Q11	Human Resources	To what extent do you agree that FTE R&D Personnel statistics show how the relative activeness of the S&T development contributes to a country? What about the per capita?	4	
Q12		To what extent do you agree that the brain-drain problem is a serious problem happening in both countries and proposes a big threat for NIS?	4	
Q13		To what extent do you agree that South Africa has very low attraction for personnel, or could we say that South Africa fails us in that aspect?	4	
Q14	Higher Education	To what extent do you agree that South Africa needs more universities?	2	
Q15		To what extent do you agree that the enormous growth in higher education enrolment	4	

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
		and graduation helps to show growth in delivering personnel to improve NIS?		
Q16		To what extent do you agree that both South Africa and China have the ability to establish the world class universities which they need?	4	
Q17	S&T Development	According to the study, to what extent do you agree that South Africa S&T development is sluggish?	5	
Q18		To what extent do you agree that the population influences the S&T development in China?	3	
Q19		To what extent do you agree that in the S&T sphere South Africa should cooperate with China?	4	
Q20	Paper Citation & Impact Factor	To what extent do you agree that paper citations relatively show the R&D level of South Africa and China?	3	
Q21		To what extent do you agree that the impact factors illustrate the essence of current R&D development?	3	
Q22		To what extent do you agree that language barriers restrict the impact factor of China?	3	
Q23	IP Right Protection	To what extent do you agree that South Africa has well developed laws in place to protect IP right?	3	
Q24		To what extent do you agree that IP protection is the biggest threat for China in the NIS?	3	

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
Q25		To what extent do you agree that Chinese trade mark protection is not as bad as other IP protection, especially the protection of famous trade marks, but still it is recognised in South Africa as a failure.	unknown	
Q26	Technology Transfer	To what extent do you agree that South Africa has made government support for research and innovation a key part of the national economic-development strategy?	4	
Q27		To what extent do you agree that TT productivity is very low in China?	unknown	
Q28		To what extent do you agree that there is big potential should South Africa and China cooperate?	5	
Q29	Government Research Institutes	To what extent do you agree that government research institutes should play the main role on S&T development in a NIS?	2	GRI's not main role players - also other bodies like Science and Technology Parks, Universities, etc
Q30		To what extent do you agree that South Africa makes GRI's more productive?	3	
Q31	Small and Medium Sized Organisations	To what extent do you agree that as the dynamics of economic growth, SMEs have not developed well in South Africa and China?	4	
Q32		To what extent do you agree that South Africa has good policies to encourage SMEs?	2	
Q33		To what extent do you agree that the BEE policy is a threat to the SMEs in South Africa?	4	

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
Q34	International Cooperation	To what extent do you agree that South Africa and China are both well involved in globalisation?	3	
Q35		To what extent do you agree that South Africa has more regional cooperation, but China is more internationalized with it?	3	
Q36	Other Factors	To what extent do you agree that crimes, HIV/AIDS, poverty are badly influencing the NIS in South Africa?	4	
Q37		To what extent do you agree that South Africa and China have the same problems of corruption that hinder the NIS development?	unknown	
Q38		To what extent do you agree that population is a threat to affect the Chinese NIS?	unknown	
Q39		To what extent do you agree that South Africa and China have opportunities to collaborate in S&T, Technology Transfer, IP protection and international cooperation fields? Does it answer research question 4?	4	

**Prof Xu ErMing**

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
Q1	Criteria	To what extent do you agree that the criteria I used in the thesis covered all factors about a country's NIS? Does it answer research question 1?	4	
Q2	Government Leadership	To what extent do you agree that government should play a core role by initiating strategies and policies in NIS?	5	
Q3		To what extent do you agree that the oversight by government is important to control the NIS?	5	
Q4		To what extent would you agree that national R&D programmes and plans are the dynamics for NIS?	5	
Q5	Strategy & Policies	To what extent do you agree that a bundle of good strategies are important to the future development of NIS?	4	
Q6		To what extent do you agree on the comparison of Chinese strategies and policies which are more focused on the international status, whereupon, South African strategies are more down to earth and concentrate on employment and national economy?	4	

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
Q7		To what extent do you agree about the verdict which was made about the implementation of policies in your residential region?	5	
Q8	R&D Expenditure	To what extent do you agree that gross R&D expenditure is a scale for NIS activity?	3	It means a lot, but cannot say it the scale to evaluate NIS.
Q9		To what extent do you agree that percentage expenditure of GDP shows how important NIS is in a country's strategy?	4	
Q10		To what extent do you agree that foreign investment figures show the attractiveness of a country to the NIS?	4	
Q11	Human Resources	To what extent do you agree that FTE R&D Personnel statistics show how the relative activeness of the S&T development contributes to a country? What about the per capita?	4	You have to think: does R&D development depend on gross FTE personnel or average?
Q12		To what extent do you agree that the brain-drain problem is a serious problem happening in both countries and proposes a big threat for NIS?	5	Strongly agree to China side
Q13		To what extent do you agree that South Africa has very low attraction for personnel, or could we say that South Africa fails us in that aspect?	-	
Q14	Higher Education	To what extent do you agree that South Africa needs more universities?	3	Numbers of universities are required by a country's need. More universities don't mean the quality of education is good. The countries



	Aspects	Questions	Scales 1~5 or Unknown	Motivation
				like South Africa, they maybe need more technique colleges and training schools.
Q15		To what extent do you agree that the enormous growth in higher education enrolment and graduation helps to show growth in delivering personnel to improve NIS?	3	
Q16		To what extent do you agree that both South Africa and China have the ability to establish the world class universities which they need?	-	I am really not sure about South Africa. But I am confident with Chinese higher education.
Q17	S&T Development	According to the study, to what extent do you agree that South Africa S&T development is sluggish?	-	As far as I know, you are right. But I don't have right to evaluate
Q18		To what extent do you agree that the population influences the S&T development in China?	3	Immense population brings develop opportunities to China. Narrow terms, you are right.
Q19		To what extent do you agree that in the S&T sphere South Africa should cooperate with China?	4	Not limited to China and South Africa only
Q20	Paper Citation & Impact Factor	To what extent do you agree that paper citations relatively show the R&D level of South Africa and China?	4	
Q21		To what extent do you agree that the impact factors illustrate the essence of current R&D development?	4	
Q22		To what extent do you agree that language barriers	3	It influences I'm sure. But it has more to do

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
		restrict the impact factor of China?		with the quality of our publications.
Q23	IP Right Protection	To what extent do you agree that South Africa has well developed laws in place to protect IP right?	-	
Q24		To what extent do you agree that IP protection is the biggest threat for China in the NIS?	5	
Q25		To what extent do you agree that Chinese trade mark protection is not as bad as other IP protection, especially the protection of famous trade marks, but still it is recognised in South Africa as a failure?	4	
Q26	Technology Transfer	To what extent do you agree that South Africa has made government support for research and innovation a key part of the national economic-development strategy?	3	How do you define Technology transfer in China?
Q27		To what extent do you agree that TT productivity is very low in China?	2	We have industrial structure problem. It is quite complicated so that you cannot just blame productivity.
Q28		To what extent do you agree that there is big potential should South Africa and China cooperate?	3	same with Q19
Q29	Government Research Institutes	To what extent do you agree that government research institutes should play the main role on S&T development in a NIS?	5	
Q30		To what extent do you agree that South Africa makes GRIs	4	

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
		more productive?		
Q31	Small and Medium Sized Organisations	To what extent do you agree that as the dynamics of economic growth, SMEs have not developed well in South Africa and China?	5	On the other hand, Chinese government just released a new group of policies to encourage SMEs development. It is important to see that.
Q32		To what extent do you agree that South Africa has good policies to encourage SMEs?	-	
Q33		To what extent do you agree that the BEE policy is a threat to the SMEs in South Africa?	-	
Q34	International Cooperation	To what extent do you agree that South Africa and China are both well involved in globalisation?	5	Very much so
Q35		To what extent do you agree that South Africa has more regional cooperation, but China is more internationalized with it?	5	I don't do much research on politics. But in economy, South Africa has no comparison to China. We have more trump cards to play.
Q36	Other Factors	To what extent do you agree that crimes, HIV/AIDS, poverty are badly influencing the NIS in South Africa?	4	Long term, definitely
Q37		To what extent do you agree that South Africa and China have the same problems of corruption that hinder the NIS development?	4	
Q38		To what extent do you agree that population is a threat to affect the Chinese NIS?	3	Once again, I know it does show bad in figures, but we are using our strength as well.

	Aspects	Questions	Scales 1~5 or Unknown	Motivation
Q39		To what extent do you agree that South Africa and China have opportunities to collaborate in S&T, Technology Transfer, IP protection and international cooperation fields? Does it answer research question 4?	4	I think there are more.