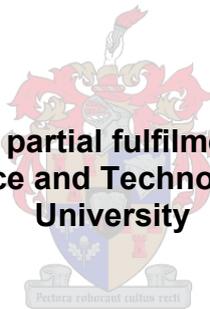


THE SCOPE AND FUNCTIONALITY OF THE NATIONAL INNOVATION COMPETITION AS AN INSTRUMENT TO PROMOTE ACADEMIC ENTREPRENEURSHIP IN SOUTH AFRICA

NONCEDO VUTULA

**Research report presented in partial fulfilment of the requirements for the
degree of Master's in Science and Technology Studies at Stellenbosch
University**



Supervisor: Professor Johann Mouton

Degree of Confidentiality: A

March 2009

Declaration

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the owner of the copyright thereof (unless to the extent explicitly otherwise stated) and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

Date: December 2008

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Noncedo Vutula

OPSOMMING

Die fokus van hierdie studie was op akademiese entrepreneurskap. Daar word begin met 'n literatuurstudie oor internasionale tendense in akademiese entrepreneurskap, met 'n besondere klem op aansporingskemas wat deur sekere lande gebruik word om innovering in akademiese instellings aan te moedig. Verbande tussen hierdie aansporingskemas en die verbetering in die vlak van innovering word aangetoon. Hierdie studie sal verder aantoon hoe sodanige innoveringsaansporings in sommige lande, soos Brasilië en Finland, tot die totstandkoming van vestigingsmaatskappye en 'n toenemende aantal patente gelei het.

Die internasionale scenario in akademiese entrepreneurskap skakel met die Suid-Afrikaanse scenario, soos uiteengesit in die hoofstuk oor die wetenskap-en-tegnologielandskap in Suid-Afrika. Die hoofokus van die Suid-Afrikaanse scenario sal op die nasionale kompetisie vir innovering (*National Innovation Competition*) (NIC) val. Dié kompetisie is 'n werktuig van die Innoveringsfonds wat in die besonder gemik is op aanmoediging en die verskaffing van innoveringsaansporings op die vlak van hoër onderwysinstellings (HOI's). Hierdie navorsingsverslag verskaf ook bevindings van onderhoude asook 'n assessering van die verskille tussen die sakeplanne wat wen en die wat nie wen nie, wat gebruik word as 'n basis vir die verskaffing van aansporings aan die winners van die NIC.

Aanbevelings word gemaak in 'n poging om oplossings te bied vir die uitdagings wat in die NIC op beide institusionele vlakke teëgekomp word, as deelnemers, en op regeringsvlak, as befonders van die NIC. Dit sal hopelik die doeltreffendheid en doelmatigheid van die NIC verbeter. Alhoewel die NIC maar net drie jaar oud is, word daar in die vooruitsig gestel dat daar op hierdie vroeë stadium areas van verbetering geïdentifiseer kan word. Gepaard met die lesse wat uit die internasionale literatuurstudie geleer kan word, sal dit 'n meganisme verskaf wat die NIC 'n kragtige werktuig sal maak vir die aanmoediging van innovering op HOI-vlak. Die gevolgtrekkings in hierdie verslag sluit lesse wat uit die internasionale literatuurstudie geleer is, in.

ABSTRACT

This study focuses on academic entrepreneurship. It commences with a literature review on international trends in academic entrepreneurship, with a particular focus on incentive schemes used by selected countries to encourage innovativeness in academic institutions. Linkages between these incentives schemes and the improvement in the level of innovations made are demonstrated. This study will also show that in some countries, such as Brazil and Finland, these innovation incentives have led to the formation of start-up companies and an increased number of patents.

The international scenario in academic entrepreneurship is linked to the South African scenario, as presented in the chapter on the science and technology landscape in South Africa. The main focus of the South African scenario will be on the National Innovation Competition (NIC), which is an instrument of the Innovation Fund specifically aimed at encouraging and providing innovation incentives at the level of higher education institutions. This research report also provide findings of interviews with different people within the academic entrepreneurship fraternity as well as an assessment of the differences between the winning and the non-winning business plans, which are used as a basis of providing incentives to the winners of the NIC.

Recommendations are made in an attempt to provide solutions to the challenges encountered in the NIC at both institutional levels, as participants, and at government level, as funders of the NIC. This will hopefully improve the effectiveness and efficiency of the NIC. Although the NIC was only started in 2004, it is envisaged that areas of improvement can be identified at this early stage. This, coupled with the lessons learnt from the international literature review, will provide a mechanism that will make the NIC a powerful instrument to encourage innovation at HEI (Higher Education Institution) level. The conclusions drawn from this report include lessons learnt from the international literature review.

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LIST OF ACRONYMS

CFI	Canadian Foundation for Innovation
CSIR	Council for Scientific and Industrial Research
DST	Department of Science and Technology (South Africa)
DTI	Department of Trade and Industry
FTE	Full-time equivalent
GDP	Gross Domestic Product
GRI	Government Research Institutes
HDI	Historically Disadvantaged Institutions
HEI	Higher Education Institutions
ICT	Information and Communication Technology
IF	Innovation Fund
ISL	Industry Science Links
MIT	Massachusetts Institute of Technology
MRC	Medical Research Council
NACI	National Advisory Council on Innovation
NIC	National Innovation Competition
NIF	New Initiatives Fund (Canada)
NRF	National Research Foundation
NSI	National System of Innovation
OECD	Organisation for Economic Co-operation and Development
OST	Office of Science and Technology (UK)
R&D	Research and Development
S&T	Science and Technology
SET	Science, Engineering and Technology
SMART	The Small Firms Merit Award for Research and Technology Incentives
SoS	Secretary of State
STEP	Science and Technology Entrepreneurs Park (India)
STI	Science, Technology and Innovation
TTO	Technology Transfer Office
THRIP	Technology and Human Resources for Industry Programme

DEFINITIONS

Academic entrepreneurship refers “to a variety of ways in which academics go beyond the production of potentially useful knowledge and undertake a variety of initiatives to facilitate the commercialization of that knowledge, which means they become active participants in designing new marketable products and take some sort of leadership role in ensuring successful commercialization” (Henrekson and Rosenberg,2000: 1).

Academic invention is defined “as a patent that lists as an inventor one individual who is employed at a particular university” (Meyer, 2004:2).

Commercialisation of research results is an attempt by academic institutions to market the research findings to generate revenue from them and thereby contribute to the economic wellbeing of the country.

Innovation chasm is defined as the innovation gap that exists between knowledge generators and the market. It is created as a result of innovation that takes place at the level of knowledge generation but that does not make it to the market. Therefore, although innovation does occur, there are no economic benefits generated from it.(R&D Strategy, 2002:35)...

Incubation is an educational process to train organisations in adequate functioning, whether the trainees are academics or persons without formal education. It involves an expansion of the academic education mission from training individuals to educating organisations. It has also been broadened from making advanced research knowledge into firms to translating knowledge at various technical levels as well as other kinds of knowledge such as cultural, artistic and management into new organisational entities (Etzkowitz et al,2005;412).

Chapter 1

SCIENCE AND TECHNOLOGY CHALLENGES IN SOUTH AFRICA

1.1 BACKGROUND

The South African science and technology (S&T) system faces a number of challenges. The system lags behind its international partners in many aspects. According to the 2005/2006 National Survey of Research and Experimental Development, the research and development (R&D) expenditure as a percentage of the gross domestic product (GDP) is approximately 0.92%, which is below the unofficial Organisation for Economic Co-operation and Development (OECD) 'benchmark' of 1% of the GDP (DST,2005/2006:,7). Yet the South African National System of Innovation (NSI) is regarded as sophisticated according to international standards, with respect to S&T policies such as the White Paper on S&T and R&D strategy. The NSI is also equipped with world-class academic institutions, science councils and research institutions. The overall administration of the NSI is done through the Department of Science and Technology (DST), which is responsible for providing strategic leadership to the other stakeholders within the NSI (NACI, 2006). The availability of the legislative framework and world-class institutions and infrastructure provides a range of opportunities for S&T to enhance South Africa's international competitiveness.

"Despite having achieved recognition as trail blazing in international technology policy circles, South Africa's national policy on science and technology has struggled to make an impact on broader debates in the economy and society"(R&D Strategy,2002:19).

According to the Innovation Fund (IF) Business Plan , "South Africa lags behind geographic regions like Europe and North America as far as having infrastructure and systems in place to drive innovation from the public sector and via public-private partnerships" (IF Business Plan, 2005/2004:6-7).

Academic institutions are also natural incubators – providing a support structure for teachers and students to initiate new ventures and other intellectual and commercial opportunities. Academic institutions also provide potential seedbeds for new interdisciplinary scientific fields and new industrial sectors, each cross-fertilising the other. A dual overlapping network of academic research groups and start-up firms, cross-cut with alliances among large firms, universities and the start-ups themselves

appear to be the emerging pattern of academic-business intersection in biotechnology, computer science and similar fields (Herrera, 2001).

Although some improvement in the state of S&T has been recorded in the past few years, R&D indicators reflect that South Africa is still below its international counterparts in many respects. According to the 2005/2006 R&D survey results, South Africa spent about R14 149.2 billion, which is equivalent to 0.92% of the GDP, on R&D. This figure reveals a steady growth in both nominal and real terms since 1993. Between 2004/2005 and 2005/2006 the total R&D expenditure in South Africa increased from R12.010 billion to R14.149 billion. This represents a nominal annual increase of about 17.8% and a 12.5% increase in real terms. This compares well with other developing countries such as India, which spent 0.61% of its GDP on R&D in 2005, and Brazil, which spent 0.91% of its GDP in 2004. However, the number of full-time equivalent (FTE) researchers remains relatively small at 1.5 per 1 000 in total employment (2005), which is marginally lower than the 1.6 figure recorded in 2004. This figure impacts negatively on R&D and innovation activities, because the low number of full-time researchers leads to low innovation activities. An increase in female researchers has been recorded from 38.3% in 2004 to 39.2% in 2005 (DST, 2005/2006:16-17). During 2005/2006 the non-profit sector employed the largest percentage of female researchers, followed by the higher education sector, then government (including the science councils) and the business sector. The biggest increase is in the business sector, from 26.8% to 29.4%, and in higher education, from 40.8% to 43.0%. The non-profit sector declined from 49.95% to 45.3% (DST, 2005/2006:7-20).

Other challenges facing the NSI are the fact that academic scientists in the country are aging and do not reflect the demographics of the country. As a result of this worrying trend, the regeneration of the national research work force has been recognised as a high priority (CREST, 2007:34). According to a recent National Advisory Council on Innovation (NACI) report entitled "Human capital and the South African knowledgebase", there is noticeable improvement in female representation in article authorship, especially in the life and agricultural sciences and engineering. Black representation in scientific authorship has also improved across most fields of sciences with significant proportions in the social sciences and especially in the field of education. However, the ageing of the publishing workforce continues to be a major concern, as more than half of article

productions in eight out of the twenty scientific fields have been produced by authors over the age of 50 (CREST, 2007:34).

As reflected in the table below, 20 fields have witnessed a significant ageing of publishing scientists over the period 1990 to 1992 and 2002 to 2004. In nine of these fields, more than half of all outputs are now being produced by authors over the age of 50. The majority of these fields are in the humanities and social sciences and the health sciences. This trend also means that production of output by authors under the age of 30 has declined significantly in all fields except for mathematics (where the small sample might have an effect on these trends) (CREST, 2007:34).

Table 1 below is a summary of author age demographics per scientific field during the periods 1990 to 1992 and 2002 to 2004 (CREST, 2007:34).

Table 1.1: Author age demographics per scientific field during the periods 1990 to 1992 and 2002 to 2004.

Scientific field	All authors				Top 20% of authors			
	% of article equivalents by persons <30 years		% of article equivalents by persons 50+ years		% of article equivalents by persons <30 years		% of article equivalents by persons 50+ years	
	1990 -2	2002 -4	1990 -2	2002 -4	1990 -2	2002 -4	1990 -2	2002 -4
Agricultural Sciences	8%	3%	23%	42%	7%	1%	24%	46%
Biological Sciences	7%	5%	20%	41%	7%	3%	21%	44%
Chemical Sciences	6%	7%	32%	47%	6%	5%	34%	53%
Earth Sciences	7%	3%	18%	42%	5%	1%	18%	47%
Mathematical Sciences & ICCT	8%	2%	21%	34%	6%	22%	0%	37%
Physical Sciences	8%	5%	34%	49%	7%	2%	35%	54%
Multidisciplinary Sciences	8%	2%	25%	53%	6%	<1%	23%	61%
Engineering & Applied Technologies	10%	5%	26%	39%	8%	3%	27%	42%
Basic Health	5%	4%	27%	42%	4%	2%	29%	48%
Clinical Health	2%	2%	31%	48%	2%	1%	32%	54%
Public/Community Health	6%	3%	32%	46%	6%	2%	31%	55%
Economic & Management	6%	5%	21%	36%	3%	<1%	22%	44%

Scientific field	All authors				Top 20% of authors			
	% of article equivalents by persons <30 years		% of article equivalents by persons 50+ years		% of article equivalents by persons <30 years		% of article equivalents by persons 50+ years	
	1990 -2	2002 -4	1990 -2	2002 -4	1990 -2	2002 -4	1990 -2	2002 -4
Sciences								
Education	2%	1%	19%	52%	1%	0%	12%	74%
Psychology	5%	3%	15%	32%	4%	0%	15%	33%
Sociology & Related Studies	9%	4%	17%	38%	8%	2%	17%	43%
Other Social Sciences	7%	3%	19%	41%	6%	<1%	19%	45%
Language & Linguistics	4%	<1%	23%	51%	2%	0%	22%	55%
Law	7%	5%	17%	38%	6%	1%	17%	47%
Religion	1%	<1%	28%	64%	<1%	0%	27%	68%
Other Humanities & Arts	4%	2%	25%	52%	4%	<1%	24%	59%

Within the higher education sector, academic staff is often forced to split responsibilities between research activities and teaching activities and there is anecdotal evidence of increasing time spent on consultancy work to augment poor salaries. The National Plan for Higher Education has led to a change in the blind-funding research allocation with a new funding formula based on publication outputs and graduation rate for master's and doctoral students introduced in 2003 (DoE, 2000). This funding formula is divided into both block grants and earmarked funds. Block grants are those funds provided by government to institutions for basic operations and maintenance costs. The formula is derived from FTE enrolment rates, which include key indicators such as teaching inputs and outputs, and research outputs. Block grant funding is used for the funding of various components within the higher education sector. Earmarked funds, on the other hand, are those additional funds that are allocated for specific purposes and allow for flexibility within the formula for new needs in the system or for new policy goals (IHEP, 2000). The National Student Financial Aid Scheme (NSFAS) is an example of earmarked funding, as its money is allocated for the express purpose of providing social redress ((DoE, 2001c).

Under this current funding framework, the Department of Education (DoE) has argued for a disbursement of funds to public higher education institutions at a ratio of 87: 13, with the bulk being allocated for block grants. Earmarked funds under the current funding framework provide for student financial support, institutional development and redress. Earmarked funds overwhelmingly support the NSFAS, which is responsible for the student loan and bursary plan (DoE, 2001c).

As a consequence of the new funding framework more pressure has been put on academics to perform. All their research and postgraduate outputs are directly rewarded, so the more they produce, the more money they earn for their universities. This performance-driven system places more pressure on individual scientists.

As reflected in Figure 1 below, it can be argued that the new research funding strategy has already led to some positive increases in pure numbers of output, as the article output of universities grew significantly in 2006 compared to previous years.

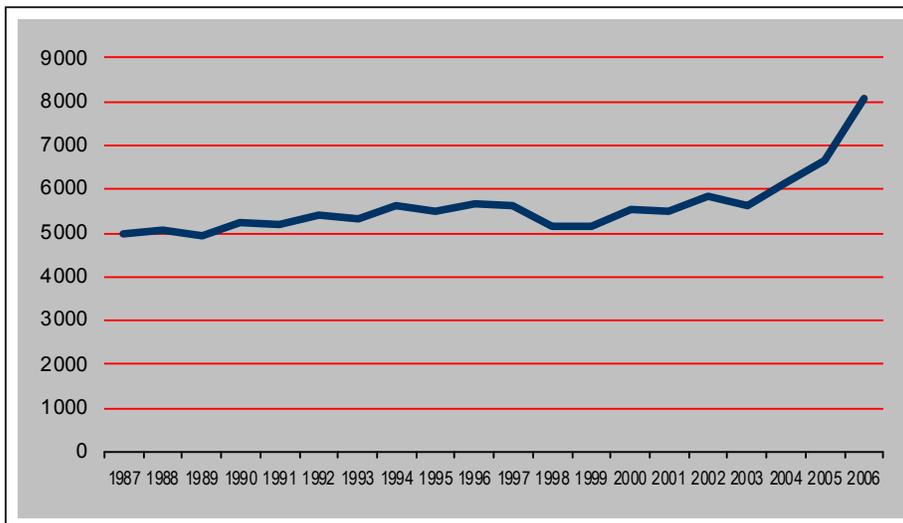


Figure 1.1: The demographics of SA Science: Trends in Scientific Output (Source: CREST, 2008)

However, there is some indication that the South African system lags behind in innovation, as measured by the technology achievement index (TAI). The TAI measures

technology inventions of countries as well as technology importation, diffusion and assimilation. This index therefore reflects either the capacity of the country for innovations or its capacity for assimilation (WEF, 2000:28). Technology inventions are measured by the number of patents granted to residents per capita and by receipts of royalties and license fees from abroad per capita. Technology diffusion of recent innovations is measured by the number of internet hosts per capita and the share of high and medium technology exports in total goods exports. Technology diffusion of old innovations is measured by telephones (mainline and cellular) per capita and electricity consumption per capita. Human skills are measured by mean years of schooling in the population aged 15 and above and the gross tertiary science enrolment ratio (UNDP, 1999).

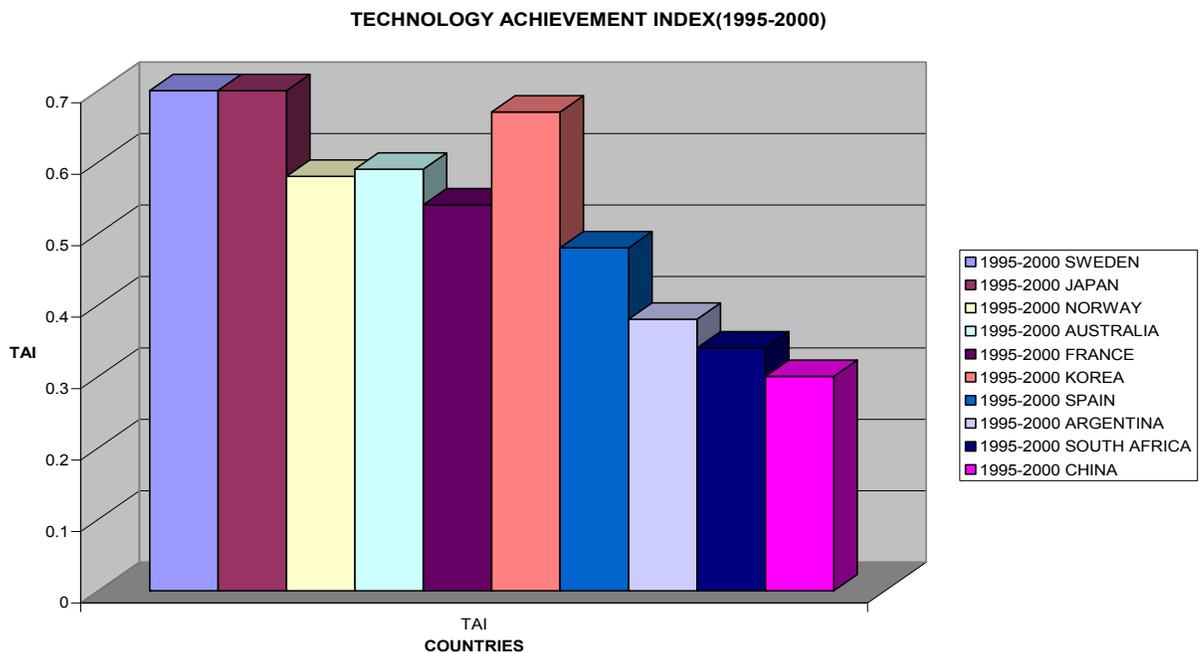


Figure 1.2: Technology Achievement Index of a selection of countries (1995–2000)

According to Kaplan,(Kaplan:2003;28) South Africa scores low on the inventions side and high on technology importation, assimilation and diffusion, as shown in the figure above. In cases where innovation occurs, it is not translated into marketable products and economic growth (R&D Strategy, 2002:20-23&35). Kaplan’s argument is confirmed by Figure 2 above, which is a graphical illustration of TAI of a number of countries, both

developed and developing, between the periods 1995–2000. As shown in the figure, South Africa's TAI ranks among the lowest at 0.34 after China at 0.30. The highest ranking TAIs are Sweden, Japan and Korea at 0.70(UNDP), 1999).

Internationally, there is reliance on Technology Transfer Offices (TTOs) based at the universities to promote technological innovation. These TTOs provide potential sites for innovation due to their basic features such as high rates of through-flow of human capital in the form of students who are potential inventors. However, some commentators argue that the TTOs in some academic institutions in South Africa are under-capacitated, lack relevant skills, have no innovation policies and there are no incentives to reward academic staff involved in innovation (Kahn&Blankley, 2005:270-296).

Despite the sound S&T policy environment, good infrastructure and institutions, South Africa's performance in S&T remains poor. This is reflected by trends in R&D and in innovations. This poor performance remains a concern for the current government. As a result, improving S&T performance in South Africa has been prioritised by the current government. This is reflected through the interventions that are currently being implemented by government, as discussed below.

When the democratically elected government took office in 1994, legislative and institutional reforms were implemented to create a conducive environment for S&T. Within government there is general acknowledgement of the link between economic growth and technological innovation (Innovation Fund Business Plan, 2005-2006:4). To encourage economic growth through S&T, the government introduced various policy instruments such as the IF and in 2004, the National Innovation Competition (NIC). Some successes have been recorded with the IF.

Since its inception, the IF has developed a diverse portfolio of technological investments, with an amount of R900 million across 173 large-scale projects. The IF investments range from the health sector (R191 million) to manufacturing projects (R99 million) and agricultural projects (R97 million). The Fund has also invested in mining and minerals, environment and safety and security sectors (Innovation Fund: Annual Report, 2004/2005:16-23).

In the field of patents, the IF successes include an increase in the demand for registration of patents, which led to the establishment of the Patent Support Fund in 2004. This fund provides wholesale joint financing of patent costs incurred by publicly-funded institutions. In 2004 a total of R2 million was paid for expenses incurred during 2003. This figure rose to R2.6 million in 2004. Another initiative implemented as a result of the growing need for patents is the Patent Incentive Fund, which incentivises researchers at publicly-funded institutions to obtain protection for their innovative ideas. At the Patent Incentive Fund inaugural awards in early 2005, 110 inventors received a total of R1 million for South African patents granted during 2003. For 2004, the figure almost doubled and the estimated awards are in the region of R2 million (Innovation Fund: Annual Report, 2004/2005:23).

During 2006/2007 a total of R17.5 million was committed for supporting patent activities through the IF. This amount caters for the Patent Support Fund, which received R3.5 million to support publicly-funded institutions, R1.5 million for the Patent Incentive Fund, R2.5 million for the support of small, medium and micro enterprises (SMMEs) initiatives and R10 million for capacity development initiatives (Innovation Fund: Annual Report, 2004/2005:23).

Table 1. 2: Progress towards targets for supporting patenting activity in 2006/2007

	TARGETED INVESTMENT	PROGRESS
Patent Support Fund	R3.5 million to publicly-funded institutions	R4.2 million granted to 10 institutions
Patent Incentive Fund	R1.5 million	28 patents granted to 11 institutions: R798 000 recommended for 2006/2007
Patent Support Fund for SMMEs	R2.5 million	Tenacent – R750 000 Jiresha – R250 000
Capacity Development Initiatives	R10 million	Patent attorneys Technology transfer Office infrastructure contract signed for R3.8 million

Despite these successes, some limitations have been identified through the IF evaluation process. One of the identified gaps is the low participation of HEIs in the IF (Innovation Fund: Annual Report, 2004/2005, 16-19). During the interviews conducted by the researcher, interviewees cited lack of capacity as one of the reasons that discourages academic institutions from developing business plans for the IF. This is particularly the case with the historically disadvantaged institutions (HDIs) that seem to be more concerned about their continued existence rather than developing business plans. The academic institutions that participate in the IF are those that have dedicated capacity to develop business plans. The NIC was introduced specifically to close the gap between innovations at university level and marketable products.

An analysis of the funds disbursed by the IF to the various types of institutions indicates that science councils, HEIs, private companies and other institutions such as non-profit organisations and public entities continue to secure funding from the IF. The institutions allocated to the 'other' category have secured R236 million in IF funding since 1998. Private companies have secured the majority of funding in this category (R179 million). From the science councils, the Council for Scientific and Industrial Research (CSIR) has been the most successful in securing grants from the IF, with a total amount estimated at 20% (R148 million) of all amounts committed by the Fund to date. The Medical Research Council (MRC), Mintek and the Agricultural Research Council have also been highly successful in securing funding. In the health sector, the IF has invested approximately R30 million in vaccines development in the 2004/2005 financial year. The Fund also provided support for the R&D of technologically innovative medical devices (approximately R40 million) for the improvement of health care. The University of Cape Town (UCT) (R51 million), Stellenbosch University (R43 million) and the University of KwaZulu-Natal (UKZN) (R40 million) have secured the majority of the funds awarded to HEIs, followed by the University of Witwatersrand, University of Johannesburg and Tshwane University of Technology (Innovation Fund Annual Report, 2004/2005:20).. From the amount of funds secured by the different institutions through the IF, the amount secured by HEIs is low. This has been the case since the implementation of the Fund in 1998, as reflected in the list of beneficiaries of the IF in 2001 listed in the table below.

Table 1.3: Projects funded by the Innovation Fund (2001)

Focus area	Project title	Institution	Total funding*
Information and Communication Technology (ICT)	Dynamic air pollution prediction system for air quality management in South Africa	CSIR	R3.33 m
ICT	New decision support software tool for growers and water resource managers: Harnessing physiological information to improve productivity and water use assessment of forest plantation	CSIR	R3.98 m
ICT	Development of expert marine geographic information system to provide environmental and economic decision support system to proposed tourism developments within and around the Greater St Lucia Wetland Park World Heritage Site	Council for Geoscience	R5.44 m
ICT	Developing a GIS-based decision support for Lubombo Spatial Development Initiative	MRC	R4.90 m
ICT	Initiate and facilitate entrepreneurial culture, capacity building and sustainable rural tourism development by using knowledge management and support technology	University of Pretoria	Awaiting final decision on funding
Value addition: Fauna and Flora (F&F)	Manufacturing high value furniture from South Africa's juvenile Eucalyptus forest	CSIR	R3.02 m
F&F	Mechanism to achieve value addition to local communities from biodiversity of conservation areas	CSIR	R3.43 m
Value addition: New materials and advanced manufacturing (VA-NM)	Smart structural health monitoring: Development of strain sensing/monitoring technology based on the use of metastable materials and the concept of integrated 'smart' structure/sensors	University of Natal	R6.03 m
VA-NM	Coal seal imaging radar	CSIR	R3.94 m
VA-NM	Local production of hydrotalcite as PVC heat stabiliser and other products from magnesite	Altona Chemicals (Pty) Ltd	R4.76 m
VA-NM	New generation low-nickel (< 2%) austenitic stainless steels for structural applications	Mintek	R3.40 m
VA-NM	Development of novel microwave system for pasteurisation of raw whole shell eggs	CSIR	R15.17 m
VA-NM	Manufacture of breathable membranes in South Africa	Breathetex Corporation	R9.21 m
VA-NM	Development of plasma technology for beneficiation and production of specialised minerals and products	South African Nuclear Energy Corporation Ltd	R9.66 m
Biotech	Bio-insecticides: Bio-rational approach to insect pest management	University of Natal	R5.88 m
Biotech	Novel antibiotics by rational drug design: Fusion of computational techniques, organic synthesis and molecular biology	CSIR	R13.06 m
Biotech	Genetic engineering of maize for increased tolerance to pests and pathogens indigenous to South Africa	CSIR	R6.19 m
Biotech	Gene therapy with Hammerhead ribozymes and recombinant viral vectors for treatment chronic hepatitis B virus infection	University of Witwatersrand	R9.14 m
*Total funding over three years in R millions (rounded off)			

The total amount of money allocated to these projects is R100.54 million. Three of the eighteen projects that secured IF funding are HEIs, namely the University of Pretoria, the

University of Natal and the University of Witwatersrand. The total amount of funds allocated for these projects was R21.05 million (Innovation Fund Annual Report, 2004/2005:16-20).

During the 2004/2005 financial year a similar trend of allocations to HEIs has been observed. During this period, the IF received a total of 56 applications for investment. The majority of these applications were from innovators in the private sector (52%), followed by private individuals (14%) and science councils. From the science councils the CSIR and the MRC received 14% of the funds. Applications from individuals at HEIs comprised 11% of the total number of applications received, while the smallest number of applications was received from government parastatals (9%). For top-down initiatives, namely R&D investments made by the IF on behalf of the DST, the investment made in 2004/2005 was valued at R77 million. This investment was split between UCT (R28 million), National Research Foundation (NRF)-affiliated institutions (R23 million), private institutions (R15 million), UKZN (R10 million), and Stellenbosch University (R1 million) (Innovation Fund Annual Report, 2004/2005:16-20). From the data of fund allocations, it is clear that the funding pattern for 2004 is similar to the funding pattern of 2001. This pattern indicates that the amount of funding secured through the IF by the HEIs is relatively low compared to other institutions. This data also shows that participation of HEIs is mainly from the previously white universities.

From the above discussions it is evident that the South African S&T is still facing a number of challenges ranging from poor performance of the S&T system (measured by R&D indicators and TAI) as well as human resource challenges in S&T (measured by the low number of R&D workforce and ageing scientists). However, the South African S&T system is known for its remarkable S&T infrastructure, sound S&T policies and internationally recognised institutions to support the S&T system. The challenges facing S&T have led to the introduction of a number of interventions since 1994 to improve the state of S&T in South Africa. Some improvement has been recorded, for example the slight improvement in the R&D indicators. One of the interventions was the introduction of the IF. The IF has recorded some successes since its inception. In this regard, it is worth mentioning the successes related to the impressive number of projects that have been successfully funded since the inception of this initiative. In addition to the funded projects a number of patents have been recorded. Despite these successes, a challenge

identified is the poor participation of the HEIs in the IF as measured by the projects that are funded through this Fund. In order to address this problem, the NIC was introduced in 2004 to specifically focus on providing incentives for HEIs to innovate.

1.2 AIM OF THE STUDY

The aim of this study is to investigate the scope of academic entrepreneurship in South Africa by examining the funding of this activity through the IF. It examines the newly established NIC, its functionality and its significance within the higher education (HE) sector. It will also provide assessment as well as perceptions of the academic sector with regard to academic entrepreneurship. This will be done by scrutinising the recently established NIC, which is an attempt to encourage universities to create innovative ideas and compete for funding. It explores in detail the incentives provided through the NIC.

1.3 RESEARCH QUESTIONS

The main emphasis of this study is to find answers to the following high-level research questions:

- ❖ Firstly, this study examines the international trends in academic entrepreneurship as an instrument for encouraging technology innovations in academic institutions. This study also reflects on incentive schemes currently in existence to stimulate technology innovations as well as commercialisation of technology innovation outputs from the academic institutions.
- ❖ On the subject of international trends on academic entrepreneurship, this study reflects on the different S&T governance structures, S&T policies as well as innovation policy instruments structures of S&T systems in the selected countries.
- ❖ The reflection on policy instruments and S&T governance structures is an attempt to look at the international best practices with regards to academic entrepreneurship.
- ❖ With regards to the South African scenario, this study focuses on specific initiatives that target the promotion of academic entrepreneurship.
- ❖ In this regard, the specific incentive scheme considered in detail in this study is the NIC, which is a funding instrument under the IF, administered by the NRF.

- ❖ As background to the status of S&T system in South Africa and the challenges, key policies are outlined and these are linked to the specific S&T policies.
- ❖ Although this funding instrument is relatively new, an attempt is made to assess its impact within the academic institutions. This is done through personal interviews, which targeted DST and NRF officials as well as academic institutions. In supporting information gathering, a detailed documentary review and analysis of NRF documents on the IF and the NIC is presented. Through this documentary review an attempt is made to scrutinise the criteria for participants in the NIC as well as the characters of the winning institutions. A reflection on the amount of funding from the IF channelled to academic institutions is also done.

The fieldwork for this study involved conducting semi-structured interviews with a selection of key informants. The broad interview questions that guided these interviews were as follows:

- ❖ What would you regard as the most important effects of the Innovation Fund on the National System of Innovation?
- ❖ Have these effects been uniform across the system or different for different institutions?
- ❖ What do you view as the main purpose of the Innovation Fund?
- ❖ What should its main goals be?
- ❖ Have these goals been realised? If so, how?
- ❖ How do you rate participation in the Innovation Fund? Which institutions participate better and for what reasons?
- ❖ What constitutes a non-winning business plan?
- ❖ What support systems and monitoring mechanisms does the NIC provide to the winning institutions?
- ❖ What mechanisms does the NIC provide to encourage further participation in the Innovation Fund?

1.4 METHODOLOGY

The concept of academic entrepreneurship is not new within academic scholarship internationally. According to Veysey (1965), the first academic revolution, which started in the late 19th century, included research as a university function, in addition to the traditional task of teaching. The second academic revolution, which took place in the late 1800s, transformed the university into a teaching, research and economic development enterprise. The Massachusetts Institute of Technology (MIT) was a pioneer in this regard, where the industry worked closely with the academic institution to create an entrepreneurial university in 1862. The entrepreneurial academic model was later transferred to Stanford, where it was introduced in the early 20th century. Similar academic entrepreneurship initiatives are currently implemented within a variety of historic university systems. The growing trend of academic entrepreneurship is an attempt to meet the widespread need to generate new firms from knowledge resources in order to stimulate employment and productivity growth ((Etzkowitz, 2002).

In implementing academic entrepreneurship, research groups are forced to operate as firm-like entities, lacking only a direct profit motive to truly make them companies. In these instances, professors are expected to be team leaders and team members are scientists in training. As group size increases, professors who formerly were doing research are compelled to devote their full time to organisational tasks. To continue at a competitive level with their peers, they must maintain an organisational momentum. Once having attained this goal, it is extremely difficult to function again as an individual researcher, so every effort is made to sustain leadership of a group (Etzkowitz and Kemelgor, 1998).

One of the advantages of an entrepreneurial university lies in its ability to generate a focused strategic direction through formulating academic goals as well as in the translation of knowledge produced within the university into economic and social utilities. One of the practical examples is the Polytechnic Milan, which is a university that established a TTO to patent and license research results. Its first noteworthy deal was equivalent to four years' salary of the faculty member. This example inspired fellow colleagues to interrogate their own research results for commercial potential. Academic institutions are routinely scrutinising research results for commercial as well as scientific potential. These academic institutions are increasingly using their internal capabilities to translate research results into intellectual property and economic activity (Clark, 1998).

Many international HEIs have embarked on academic entrepreneurship to remain relevant and to create self-sustainability. However, the promotion of academic entrepreneurship through the NIC is a new funding instrument in the South African S&T system. Since no previous work has been done in this area in South Africa, there is little or no data available. This was identified as a challenge for the study. It is envisaged that this study will contribute to the understanding of this phenomenon in South Africa (Mouton; 2004:148).

In doing this study, primary and secondary research was undertaken. Primary research was undertaken in the form of in-depth interviews with individuals from the institutions that have submitted applications for the NIC in 2004 and 2005. In particular, team leaders of the projects that have applied for the innovation competition were targeted, as it was assumed that they would provide in-depth and first-hand knowledge on the project. It was envisaged that in-depth interviews would allow a detailed exploration of issues rather than being limited by structured questions. However, to assist with the configuration of the interviews, a schedule of questions had been drafted. The questions also allowed the interviewer space to add other questions that might have arisen from the interviews.

In addition to the participants in the NIC, key staff members of the IF, the NRF and the DST were interviewed. This was an attempt to complement the findings from the applicants by getting opinions of the sponsors. To add value to this initiative, the announcements, policy statements, reports, media coverage and budgets of the above-mentioned institutions were also analysed. This was an attempt to test the consistency between the stated objectives of the funds as per policy positions, announcements, etc. and outcomes of the application of the funds with an intention of obtaining a detailed picture on the NIC.

In the literature review the researcher specifically focused on similar innovation incentives provided by governments internationally to HEIs. The selection of countries includes developed countries (e.g. Canada and the United Kingdom (UK)) and developing countries (e.g. Brazil). The literature review provides the necessary context to assess how South Africa is doing with regard to academic entrepreneurship. It also gives some indication of South Africa's alignment to international best practice. It is

shown through the literature review that the problem of low innovation outputs at HEIs is not unique to South Africa. It is also shown that academic entrepreneurship as a solution to low innovation at HEIs is an international trend.

Once the international trends have been discussed, the focus shifts to the South African S&T landscape. This includes discussions of the policy and institutional framework, challenges in the NSI as well as key funding instruments for the NSI. Special attention is paid to the newly established NIC as a government initiative to promote academic entrepreneurship. The primary sources of information in this regard are the business plans submitted by the different institutions to the NIC. The competition requirements as well as the criteria for selection of the winning business plan are also used as sources of information.

In addition to analysing these documents, the business plans of the 2004 and 2005 winning institutions have been used as further source material to augment the analysis. The Stellenbosch University business plan (the winner of the 2004 competition) was used as primary source in this regard. The use of the winning business plans is an attempt to answer the questions relating to what constitutes a winning business plan. A comparison of the winning business plan and the non-winning business plan is made. The intention was to gain insight into similarities as well as differences in the business plans and other related processes. The case studies will also highlight the key components of the winning business plan. This can be used in future as a model business plan by prospective applicants for the NIC.

1.5 LIMITATIONS OF THE STUDY

As already mentioned in the methodology section, one of the limitations of this study is the fact that the NIC is new in the South African S&T system. Other than official documents from the participating universities and the NRF as an implementing agency, there is very little information on the NIC. To overcome this limitation this research study proposed to collect data through primary and secondary research. It is also acknowledged that sources of information are limited. However, the researcher believes that adequate information has been collected through in-depth interviews. Making use of the winning business plans as case studies complements the interviews and the literature review.

1.6 DATA ANALYSIS

Data analysis was done on completion of each phase of this research. The literature review presents insights into international trends in academic entrepreneurship. The analysis of the next phase of this study, namely the S&T landscape in South Africa, provides an outline of the policy and institutional framework as well as challenges facing the NSI. It also provides a context in which the NIC, as an instrument to promote academic entrepreneurship, operates in South Africa.

Chapter 2

INTERNATIONAL TRENDS IN ACADEMIC ENTREPRENEURSHIP

This chapter examines the role of academic entrepreneurship in promoting innovations internationally by exploring international trends in innovation incentives schemes. It interrogates select government policies designed to encourage academic entrepreneurship with a specific focus on international best practices. It also looks at the incentives schemes and funding instruments that are used by different countries to encourage academic entrepreneurship and innovations. The literature reviewed indicates that there is a positive relationship between active academic entrepreneurship and high innovations. This positive relationship is largely influenced by the innovation policies of the different governments, the different funding instruments used as well as a range of fiscal and non-fiscal incentives utilised by the different countries. This chapter will highlight the different S&T governance structures, S&T policies as well innovation policy instruments. The countries selected include both developed (such as Canada and the UK) and developing countries (such as Brazil).

2.1 BACKGROUND

It is acknowledged internationally that universities are a major source of breakthrough in science and innovative technology, often with significant commercial application. Many universities are becoming more involved in commercialising their technology by creating small enterprise companies. However, universities are faced with priorities other than technology commercialising efforts. These range from educational diversification and faculty attraction and retention to student attraction and retention (Boesch and Mihalasky, 2003). This implies that academic institutions have more urgent priorities other than focusing on technology innovations and the commercialisation of technology research outputs.

Most countries in the world are shifting to knowledge economies, as they acknowledge the need for continuous information generation. Innovation is viewed as the engine of technological change and economic growth. A lot of emphasis is placed on innovation policies as a cornerstone for economic development. Academic institutions in particular play a critical role in knowledge generation that drives the economies of the world. These institutions have become more than just institutions of higher learning. They are

also proactive contributors to technological development and economic growth. The notions of the entrepreneurial university and academic entrepreneurship have become guiding principles for decision makers in S&T policy and the higher education sector (Meyer,2004). Many countries have designed policies to increase entrepreneurial activities and support the commercial uptake of university-generated technologies. University spin-offs and academic start-up companies are regarded as some of the most appropriate vehicles for the utilisation and commercialisation of research results (Meyer, 2004).

More often than not, universities focus on research competitiveness, which usually requires the development of concrete and sensible strategies to achieve certain targets. It is also widely acknowledged in the economic literature that the performance of any economy is not only dependent on public and private investments but also on the intensity of the interactions and learning processes among producers, users, suppliers and public authorities. A common concern within the academic institutions is the availability of adequate incentives for the knowledge generators in the academic world to disclose their inventions (Centre for Innovation Research, Oslo, 2003). One of the vehicles commonly used internationally to promote academic entrepreneurship is TTOs. These are used to pool innovations across research laboratories. However, if a stream of innovations is too small, the TTO may not be able to keep up with the market demands (Debackere and Veugelers, 2004:321-324). Other countries focus on providing incentives to university scientists to enable them to devote some of the time they would have spent on fundamental research to do income-generating applied research for private firms (Beath et al, 2003:1309).

As companies seek new ways to collaborate with academic research groups, universities want to expand their role in the economic development of their region. Various ways have been created, such as the graduation of students and consultations, to bridge the gap. The creation of intermediary offices, spin-off firms, science parks, incubators and other interface mechanisms has raised a new set of issues about the role of academia in society, beyond traditional concerns about community service, on the one hand, and academic freedom, on the other. Conflicts of interest, intellectual property and limited secrecy are among the new terms of policy debate among academics, government science policy officials and industrial laboratory

directors. Just as universities have internalised a technology transfer function, corporations that traditionally left technology not directly related to their strategic direction 'on the shelf' now view it as a business opportunity. Large firms with tech-transfer capabilities, in both the United States and Japan, are also becoming involved in the firm formation business. Hereby they follow the path of universities, whose initial involvement in technology transfer took place through licensing to external sources, and then moved on to include the creation of new firms from faculty- and student-generated technologies.

Young scientists are now advised to stay at university where there are students who can work with them to develop new technologies. Universities also offer their infrastructure to develop technologies to the next stage and there is support from the university and even academic credit. The universities act as incubators and increasingly have their own venture funds and therefore even the financing for a faculty- or student-organised firm could come from the university taking the role of venture capitalist (Etzkowitz & Leydesdorff, 1998).

In support of the argument of the growing trend of academic entrepreneurship, Etzkowitz (2002) present a global scenario with evidence that entrepreneurial universities have emerged under different academic and social conditions from different parts of the world. These entrepreneurial universities have emerged in Europe, Latin America and Africa. In most instances academic entrepreneurship is viewed as a natural extension to the entrepreneurial dynamic that has been built into academic institutions from inception. In these instances university professors are responsible for obtaining their own research funds from funding agencies giving out funds based on peer-reviewed proposals and programme director initiatives. This is viewed as one of the contributors to the culture of academic entrepreneurship (Viale and Etzkowitz, 2002:20). In some instances, the system is strongly characterised by state control in encouraging academic entrepreneurship. Entrepreneurial universities are established as a direct result of a mission set by government. In Sweden, for example, the focus is on training students to develop start-ups, with the professors acting as advisors to the new start-up firms. The Swedish entrepreneurial academic model focuses on changing the academic culture by empowering students (Viale and Etzkowits, 2002:20).

In other instances academic entrepreneurship is largely observed in partnerships between HE and the private sector, which includes research collaboration, technological licensing and overheads. The income from entrepreneurial activities is sometimes not large and national and private universities rely heavily on funding from student fees. Their activities are confined to technology transfer and licensing on the basis of partnerships with the private sector. In this instance, academic entrepreneurship is linked more to accountability, partnerships and contributing to the economy rather than profit making (Yykoyama, 2006:524). In the UK, academic entrepreneurship activities have become prominent. These include partnerships with the private sector, investments in the stock exchange and corporate activities. These activities in UK are directly linked to fund-raising initiatives, which were started after the fund-raising crisis in the 1980s. These fund raising-initiatives do not always achieve successful profit gains (Yykoyama, 2006: 525).

The Brazilian model diffuses entrepreneurship throughout the university through courses on entrepreneurship. An example is examinations on the writing of business plans for all students in the Pontifical Catholic University of Rio de Janeiro. Other universities have adopted the incubator system to broaden organisational training tasks. Incubators from high-tech firms fill gaps in traditional clusters and establish consulting firms that perform a modernising function, transferring high-tech knowledge to low-tech firms. Incubation serves a variety of other organisational needs in Brazilian society, such as forming co-operatives to create employment and address issues of poverty (Viale and Etzkowitz, 2002:20).

In Africa, there is evidence that entrepreneurial universities have emerged as a result of innovation crises. In the 1990's in Zambia, when the telecommunications system broke down, the university computer centre stepped in and set up an internet service provider, which was later established as a firm. This event is currently being generalised into a broader academic and national development model. The purpose is to set a virtuous circle in motion in which academia is transformed from a cultural entity that consumes the surplus of a society into a productive force that generates new resources (Viale and Etzkowitz, 2002:20-21). In South Africa, through the NIC, a number of TTOs has been established to encourage entrepreneurial universities (National Research Foundation, 2005/2006).

Some commentators argue that less attention has been paid to the development of enterprising teachers and their pedagogy. They argue that more attention is required to explore the aspects of human capital and organisational change and transformation in academic entrepreneurship. An example from University of Derby in the United Kingdom, which has been successful in the development of entrepreneurial team, reveals the importance of building a team for academic learning. From this case study, enterprise learning should include development of a curriculum at undergraduate, postgraduate and doctoral levels. It should also include learning and assessment methods, funded enterprise projects for students, graduates and the local community, practice based research in entrepreneurial learning and the participation in internal and external networks of educators, practitioners and influencers (Rae et al; 2007:9). A dedicated team, which includes entrepreneurs, students and academics, was established in the case of University of Derby to drive academic learning. Some of the aspects embraced by this team include the development of special enterprise courses as part of the curriculum. Of equal importance is the continuous engagement of students in enterprise learning activities. The focus of these engagements is enterprise learning activities such as student and graduate enterprise extracurricular events and societies, which are forums for students and graduates to devise creative ideas and to turn those into successful business enterprises. These engagements also include business plan competitions, provision of bursaries for entrepreneurship coaching and continuous support. This type of learning encourages lifelong learning and widened access to HEI's (Rae et al; 2007:15-21). This form of learning has proved to be successful in increasing the number of students learning in enterprising ways. In some instances enterprise learning has been connected with incubation support for emergent graduate enterprises, and new ventures linked to the university have been created. These programmes were also linked to new connections between enterprise, educational and commercial policy agendas including careers, innovation in teaching and learning and assessment methods, business incubation, external income generation and community development, staff development and research. By doing this an increase in the impact on entrepreneurial learning and results were achieved. Despite this success some work needs to be done to extend enterprise learning across the curriculum for all students (Rae et al; 2007:22).

From the above discussion, it can be argued that the growing trend of academic entrepreneurship is a global phenomenon. It has emerged in response to economic and social needs. In support of this emerging trend different countries are using different strategies to promote academic entrepreneurship, as they realise the benefits of embracing this concept. Academic institutions have embraced this concept in their quest for knowledge generation and provision of practical solutions to societal problems as well as other benefits related to financial independence. The dilemma that continues to exist within the academic institution is the need to strike a balance between basic research and applied research as collaboration between government, industry and academic institutions become a necessity for successful innovations. An interesting scenario has emerged, which emphasises entrepreneurial universities to work as teams with different backgrounds who work interdependently as entrepreneurs within and beyond their organisations, who act both strategically and operationally and who connect different people and agendas together into a coherent stream of enterprising activities which create new value, both financially and in the forms of learning, innovation, culture for the university and for students, staff and external partners.

2.2 THEORETICAL INSIGHTS

Innovation policies are usually influenced by what is termed the 'systematic approach' to industrial innovation (Edquist, 2001). Economic theories provide an explanation for the need for policy interventions. Such interventions are largely influenced by the need to provide policy interventions against market failure and system failure (Edquist, 2001 : 4-5). These two failures are not mutually exclusive and therefore require similar policy interventions. Technology policies intervene through managing the science base and designing financial incentives to industrial R&D as solutions to market failures. The market failure theory argues that private firms are likely to under-invest in R&D because they are unable to keep all the benefits to themselves. In other words, their competitors are also able to benefit from the new technology, innovation or knowledge. This is more applicable where innovation leads to small incremental change of products, services and production techniques. For society in general the spill-over effect may be beneficial as it may contribute to an increased productivity in other parts of the economy. To support the social returns, policy makers develop business R&D support schemes. In practice, however, the market failure theory is not always applicable. New products and

innovations that are not available to competitors make the firm with those products and innovations more competitive than others. Firms will do anything to keep their competitive edge. However, this practice is not sustainable because it confines firms to individual activities, which may be obsolete, therefore affecting or limiting economic growth. Because of this, firms often voluntarily disseminate their proprietary technologies, even to their rivals, provided that the reward is sufficient (Edquist, 2001). By co-operating they obtain trading partners, and they usually have adequate information to judge whether their competitors will benefit more from their inventions than themselves. The market failure argument says nothing about the optimal rate of R&D. This argument is still very useful for innovative companies to play an important role in generating the tax base and employment and therefore the welfare of the state. These companies can also provide society with new socially beneficial products, processes and services and solutions to social and environmental problems. The social rate of return may therefore be higher than the company's profitability return from an R&D investment (Edquist, 2001).

The systematic failure theory, on the other hand, considers innovation to be a key element in economic growth (Edquist, 2001). According to this theory, technological change occurs in two phases. Phase one is the innovation and phase two is the diffusion of the innovation. This theory advocates for the constant interplay and mutual learning between different types of knowledge actors. While searching for new innovation opportunities, firms gain from linkages with other knowledge-generating organisations such as universities. Technology innovations can be slowed down if there is poor interplay among the knowledge-generating institutions. System failure occurs when there is a mismatch between elements in the innovation system. Systematic innovation policies are about facilitation of the emerging new technology and innovation opportunities by building innovation infrastructure. Policy makers therefore strive to create institutional structures that support the innovation processes in firms.¹ Governments are encouraged to intervene if there are such failures. Institutions such as universities and research institutes play a major role in facilitating innovations. These are referred to as hard institutions. Laws, regulations, culture, attitudes etc. are referred to as soft institutions. These play an equally important role in creating an enabling

environment for knowledge generators to share knowledge easily (Henrekson& Rosenberg, 2000:30-34).

The discussion on theoretical framework above makes reference to the important role played by innovations in economic development. It also makes reference to the role that government policy interventions play in creating a favourable environment for innovations to take place. These interventions are efforts by governments to prevent market failure and system failure.

At the level of practical application of the theoretical framework there is evidence that academic institutions play a central role in knowledge generation and ultimately innovations. This dates back as far as the 19th century, as explained in the history of the academic revolution. According to this history, the first academic revolution took place in the late 19th century. It made research a university function in addition to the traditional role of teaching (Etzkowitz, 2003:110). Clark 1996 refers to this phase as the substantive growth in universities, which occurred on a much larger scale in some countries than others. A growing governmental interest in notable scholarships helped to propel a major expansion-based growth in knowledge generation before enlarged consumer demand started. This was coupled with increased funding for research. Substantive growth is characterised by an increased number of students. It is knowledge-based and generated largely by research. Reactive growth, on the other hand, is student demand led and generated by student enrolment. These two types of growths are often in conflict and they set systematic dilemmas for higher education (Clark; 1996:417-424).

The second academic revolution transformed universities into teaching, research and economic development enterprises. An example of this transition is drawn from the MIT, which was founded in 1862 as a land grant university. This academic entrepreneurial model was then transferred to Stanford, where it was introduced into the liberal arts university culture in the early and mid 20th century. An entrepreneurial model, known as the entrepreneurial academic format, has been fashioned from a variety of historic university systems to meet the widespread need to generate new firms from knowledge resources in order to stimulate employment and productivity growth (Etzkowitz, 2003:110). This entrepreneurial model is accepted globally as the future of the academic institutions.

Despite this widely accepted entrepreneurial model of academic institutions, Martin and Etzkowitz (2000) presented two contradictory views on the future of universities. One view argues that the future of universities is under threat from governments and those expecting universities to do more useful things such as producing more applied knowledge and develop more useful skills in its students. This view regards new entrants as a threat to the autonomy of the universities(Martin and Etzkowits,2000:9)., Some of the threats include a view that more demands will be made by the private sector for universities to produce more applied knowledge, which will lead to a shift from universities away from producing basic research. This implies that there will be a shift from mode 1 to mode 2, with more knowledge being produced in mode 2 in the context of applied research (Martin and Etzkowits, 2000:9). The other threat is viewed as the general trend of globalisation, combined with the development of communications and information technologies and the changing demands of students for continuous and improved lifelong learning. As a result of the changes in demands, new entrants in the higher education market have emerged. A third threat is the possible weakening of the relationship between research and teaching. As more pressure is put on improved and more efficient methods of teaching, this puts a strain on research, as it receives less attention (Martin and Etzkowits, 2000:9).

Some commentators argue that the new entrants in the university space enhance universities to make meaningful contributions to the knowledge-based economy. In this environment, universities become the primary source of new knowledge and skills required for the knowledge economy. Instead of losing their autonomy, it is argued that universities become more powerful. This is attributed to a shift in the changing nature of knowledge production in universities, from mode 1 to mode 2. However, other commentators argue that this shift is not from mode 1 to mode 2, but it is rather a shift in the balance of knowledge production between the already existing forms of mode 1 and mode 2 productions. The knowledge production therefore consists of the combination of the two modes (Martin and Etzkowits, 2000:9).

In support of the model of entrepreneurial university, Martin and Etzkowitz (2000) have argued that this shift in knowledge production is attributed to the emergence of a triple helix model. In the triple helix model universities are seen to be taking on a new

responsibility of contributing to the economy, in addition to the traditional roles of teaching and research (Martin and Etzkowitz, 2000:13). This is also known as the third academic revolution, “in which the entrepreneurial university becomes the centre of gravity for economic development, knowledge creation and diffusion in both advanced and developing societies” (Viale and Etzkowitz, 2002:2). This is caused by increased scientific density but also by change in academic functions. These changes became more prominent in the 20th century, which was characterised by changes in the process of innovations with the emergence of corporate university- and government-sponsored R&D. This phase is also referred to as the institutionalisation of innovation and is characterised by the birth of the entrepreneurial scientist (Viale and Etzkowitz, 2002:5).

At this point it is important to take a step back and provide a brief explanation of the single helix and the double helix. The single helix occurred mainly during the first industrial revolution, during which knowledge was less formalised and was made of practical know-how generated by individual experiments and trial and error. During this era, knowledge was based on simple empirical mental models linked to accidental generalisations. Knowledge was also characterised mainly by pragmatic schemes that were part of the rules of action that drove practical know-how. Under the single helix, there was a lot of tacit knowledge that made the collaboration and dialogue between inventors difficult. The organisation was made up of isolated individual inventors. There was little collaboration within universities and almost no collaboration between university and industry (Viale and Etzkowitz, 2002:8).

The double helix was characterised by explicit knowledge and less tacit knowledge than the first revolution. Collaboration between academic institutions and industry was still difficult, but there were different methodologies and rules used by industry and the academia. There were also different objectives between industry and the academia. There was a strong realisation that industry had no technical know-how to solve all the problems and therefore there was a need to interact with the academia. The second industrial revolution was characterised by weak interaction with government, except in the army (Viale and Etzkowitz, 2002:9).

The triple helix is characterised by the realisation of a need for close co-operation between academic institutions, government and industry. In an effort to minimise the

problems referred to in the single and double helix, close co-operation between the three players is encouraged. The initial relation between firm and university was centred in the doctoral students that are trained at the university and are employed in the corporate laboratories. In the second scenario the entrepreneurial university is acts as a generator of spin-off firms. The university encourages the dual academic career which goes beyond the traditional truth-seeking scientist to the entrepreneurial scientist who is able to interface knowledge and innovation. This minimises the problem of non-translatibility of knowledge, unavoidable gaps in tacit knowledge and divergence in awareness of commercial potential. As triple helix evolves, institutions, organisations and roles are transformed. New roles and responsibilities are defined. Some of the transformation aspects under the triple helix include a need to transform technology transfer to create marketing and business development capacity. As individual academics become involved they perceive their findings in a new way, seeking out the practical as well as the theoretical implications of their work (Viale and Etzkowitz, 2002:13).

As already mentioned, the emergence of the triple helix of university-industry-government relations is becoming as a common trend that cuts across boundaries. This trend is based on the creation of entrepreneurial universities. The academic institutions are becoming central in the innovation process and supersede many functions of the industrial enterprise. These universities are becoming important platforms for societal transformation (Viale and Etzkowitz, 2002:13).

In support of the growing trend of academic entrepreneurship, Clark (2000) argues that with the growing demands on academic institutions to become entrepreneurship there is an inherent demand for academic institutions to undergo internal transformation. Academic institutions, in their quest to transform, should endeavour to be self-initiating, self-steering, self-regulating, self-reliant and progressive. Furthermore, Clark (2000:10) argues that the defining characteristics of entrepreneurial universities are their ability to stand on their feet in order to adapt on their own terms to a highly complex and uncertain world. In addition to this, transformation to academic entrepreneurship should strengthen university collegiality, autonomy and university achievement. It has also been highlighted that in order to be successful, transformation should be driven by universities instead of national governments. In order for universities to transform and meet the new challenges of academic entrepreneurship it is important that they have more than one

stream of funding. Clark (2000) highlights three streams of funding that are necessary to facilitate transformation to academic entrepreneurship. These are other government departments, e.g. forestry and agriculture; other private organised sources, namely industrial firms, professional and civic organisations that promote continued education for their members and philanthropic foundations; and lastly university-generated income, e.g. income from endowment and investments, student tuition and fees as well as alumni(Clark,2000:13).

These different sources of funding have their problems and opportunities. Funding from private sources such as industrial firms has strings attached, as private firms want something for their money and are often specific about what they want. University-industry collaborations often involve bargaining over contracts and compromises over whose interest has priority. Other government departments may offer generous unearmarked funding or they may insist in segmental budgeting and tight accounting measures. The university-generated budget usually comes with fewer strings attached (Clark, 2000:18).

As already mentioned, a number of international academic institutions are currently undergoing transformation to become entrepreneurial. This process is generally viewed by the academic institutions as a life cycle. Steps taken by academic institutions in this process of transformation include improving entrepreneurial capacity and human resources. There is a general need to acknowledge that this is a process and not an event. There is also a need for integration within universities instead of having big faculties that do not operate together as a unit. The integration process should encourage universities to take collective choices and collectively face the consequences of collective actions. Universities continue to call for autonomy. However, once they have autonomy, they should be able to utilise it to the fullest. This should include the ability of universities to diversify their income base as well as embrace the culture of academic entrepreneurial. This should be done through building self-reliance and collective awareness of building a forward-looking character (Clark, 2000: 21).

From this background it can be argued that there is a growing trend among academic institutions internationally of shifting away from pure academic research to focus more on research that generates economic viability and sustainability. This shift in focus often

requires academic institutions to make choices between focusing on academic research, research excellence and prestige and becoming profitable entities. From the literature reviewed, it is evident that these changes resulted from changes in the political and economic landscape. At the economic level, academic institutions played a major role in the shift from industrial revolution to post-industrial revolution. These institutions are responsible for producing professionals and new technologies and products are created at these institutions, often through partnerships with business, through funding provided partly by the state. As the magnitude of globalisation increased, pressure increased on the national higher education policies to change the way higher education institutions do business, and in particular had a major impact on changes that occurred in the higher education sector (Slaughter and Leslie, 1999:24-27&34). As a result of political and economic changes, government policies have been adjusted and developed to accommodate the changes, as most countries are shifting to knowledge economies and put emphasis on innovations and technology development for economic development.

As academic institutions are setting themselves to meet the new challenges and demands, it is important to note that there is a need for internal transformation within the academic institutions. In undergoing this internal transformation, it is important that academic institutions take the lead in shaping their outlook instead of waiting for governments to prescribe to them. It is also important to consider that the changes brought about as a result of academic entrepreneurship should not force academic institutions to choose one role over another. In other words, both basic and applied research can be performed simultaneously. Academic institutions should also structure themselves appropriately to be able to benefit from the new challenge of knowledge generation for economic development. In this way they will enjoy autonomy and become indispensable.

2.3 THE INTERNATIONAL LANDSCAPE ON FUNDING INSTRUMENTS AND INNOVATION INCENTIVES

2.3.1 THE UNITED KINGDOM

As a result of globalisation and the need to respond to global competition, the higher education system in the UK made some adjustments to accommodate the changes in

the 1980s. These changes ranged from changes in higher education policies, financial aid policies as well as promotion of academic capitalism, as elaborated upon in the discussion that follows. The system changed from being an elitist binary system, which had more students in the lower tier, to a unitary system with more students at postgraduate level (Slaughter and Leslie, 1999:41). Research at higher education institutions moved from curiosity-driven basic research to more initiatives aimed at driving industrial competitiveness. The changes were given more power in the 1980s during the era of Margaret Thatcher, who cultivated the enterprise culture in higher education. The sector was also encouraged to manage its affairs more efficiently and create structures to suit this new work environment. Business leaders also played a prominent role through the Council for Industry and Higher Education. The Council members included heads of large corporations and heads of the higher education sector. Through the Council, the link between R&D initiatives and economic development was established (Slaughter and Leslie, 1999:41). Legislative reforms were also introduced in the 1980s in the form of the Education Act of 1988, which promoted higher education and industry linkages for economic development. In 1992, the binary system, which distinguished between traditional universities and vocationally-oriented polytechnics, which did not have the right to confer academic degrees, was abolished by the Department of Education and Science (DES). Teaching and research were separated. Teaching grants depended on the number of students and outcomes, while research grants were opened up for competition. Government science and technology research focused on university-industry relations with a specific focus on exploitable areas of science. These policies led to a shift of research resources to specialised interdisciplinary research centres such as the Agricultural and Food Research Council, the Institute of Food Research, the Anita Mehta Interdisciplinary Research Centre in Materials for High Performance Applications and the University of Birmingham.

These centres had to go through competitive bidding in order to win research resources. This competition led to increased patents and technology licensing programmes. This point was further emphasised by the White Paper on Science and Technology in 1993, which encouraged universities to make a more direct contribution to wealth creation through research (Slaughter and Leslie, 1999:43).

Currently, the S&T system in the UK falls within the ambit of the Department of Trade and Industry (DTI). The DTI is responsible both for UK Science Policy through the Office of Science and Technology (OST) and for the promotion of development and use of technology by industry. The mission of OST is to support excellence in science, engineering and technology (SET) and their uses to benefit society and the economy. The Secretary of State (SoS) for Trade and Industry has overall responsibility for the government's science policy and support for S&T in his/her cross-departmental role as the Cabinet Minister for Science and Technology. The SoS strives to strengthen the UK's S&T capabilities and to maximise the contribution to sustainable growth and quality of life in the UK (www.infoexport.gc.ca). The OST is headed by the Chief Scientific Adviser (CSA) and is responsible for developing and co-ordinating government policy on science and technology, both nationally and internationally. The OST is also responsible for the allocation of the science budget, which was just under £2.4 billion per annum in the late 1990's, to research via the research councils, for which the Director-General of the Research Councils (DGRC) is responsible. The OST is split into two groups, namely the Science and Engineering Base Group (SEBG) and the Trans-departmental Science and Technology Group (TDSTG) (www.infoexport.gc.ca).

The government's most recent policy and priorities for SET are articulated in a document entitled *Investing in innovation: A government strategy for science, engineering and technology* (2004). This strategy sets out five prominent themes, as mentioned below:

- Strengthening university research
- Enhancing skills
- Knowledge transfer
- Innovation in business
- Enhancing government science

In general terms, the UK's science policy can be broken down into three broad objectives:

Excellence in science: The government of the UK maintains and enhances the excellence of its science base. This is done through funding basic and strategic research. In its efforts to fund research, the UK government has a dedicated capital funding stream worth £500 million a year from 2004–2005 budgeted to renew research

infrastructure for science at UK universities. It has also increased the budget for large-scale facilities. The UK government has also rolled out a roadmap to provide a long-term vision of future requirements for such facilities. An amount of £120 million per year from 2005/2006 has been allocated to make a larger contribution to the indirect costs of research in universities (www.infoexpo.gc.za).

Opportunities for innovation: The government plays a crucial role in providing the incentives, mechanisms and resources to exploit the science base and to enhance the demand for technology and investment in R&D from business. A number of initiatives has been introduced in recent years, aimed at universities, business, government departments and regional development agencies alike. These include:

- The University Challenge Fund, which provides seed venture funding for spin-off companies.
- The Science Enterprise Challenge, which brings business and entrepreneurial skills into the science curriculum. This is run in collaboration with the new Cambridge-MIT Institute.
- The Higher Education Innovation Fund (HEIF), which is meant to develop the capacity of universities to improve interaction with business and the community.
- The Public Sector Research Establishment Fund, which encourages exploitation of S&T and provides access to seed funding.

Since these are all instruments that have been put in place to incentivise innovation within public R&D institutions, they will be elaborated on in some detail in the following sections.

The University Challenge Fund

The University Challenge Fund Scheme (USFS) was introduced by the Chancellor of the Exchequer in March 1998 as collaboration between the government, the Wellcome Trust and the Gatsby Charitable Foundation to assist universities in turning research projects into viable businesses. All universities were invited to apply at the launch of the fund in June 1998. Collaborative bids involving other HEIs and public sector research establishments were also invited. The objective of this fund is to provide finance for supporting the initial commercialisation activities for new technologies emerging from

universities and research institutes. There has been a funding gap in the provision of finance for bringing university research discoveries to a point where their commercial usefulness can be demonstrated and first steps taken to secure their utility. The UCSF fills that gap. The purpose of the University Challenge Fund is to enable universities to establish seed funds, which assists successful transformation of good research into good business. It provides initial funding of the research, which is the riskiest stage of the venture process. This Fund also allows the winning universities ready access to seed fund capital to turn the results of research into potential new businesses and/or products. It also helps in catalysing the activity in seed funding of high technology, an area still not well served by the UK venture capital industry. It is responsible for educating UK universities in the investment process, brings the financial community closer to universities and provides stimulus to entrepreneurial activities in the university sector. The UK government has suggested that the availability of seed funds can help the commercialisation process in a number of ways, such as financing access to managerial skills, securing or enhancing intellectual property, supporting additional R&D, constructing prototypes, preparing business plans and covering legal costs (www.innovationg-regions.org).

The funding of the project comes from its three founders. Initially the government contributed with £25 million, the Wellcome Trust with £18 million and the Gatsby Charitable Foundation with £2 million. The total funding available was therefore £45m. In 2000, the Government's contribution was increased by £15m, with £5m for the first round and £10m for a second round following the large number of very good quality applications to the Fund. Furthermore, each recipient university of a University Challenge Seed Fund had to provide 25% of the total fund from its own resources (www.innovationg-regions.org).

The first University Challenge Competition created 15 seed funds, allowing 37 institutions (31 universities and 6 institutes) access to investment capital. The total value of the funds created (including the 25% matching funds required from the participants) was in excess of £60 million. The seed funds established from the first competition were between £1m and £5m with the ability to make single investments to a maximum of £250 000 per investment. The progress of the funds has been monitored through annual reports. The 2000/2001 annual report showed that £11.9 million of investment was committed. A total of 143 projects have been supported by the 15 seed funds with an

average investment of £83 000. The University is the trustee for the funds, which are held in a dedicated account (www.innovationg-regions.org). This fund is viewed as a successful innovation incentive.

The Science Enterprise Challenge

The Science Enterprise Challenge (SEC) was launched in 1999/2000. The main objective was to establish world-class centres for the commercialisation of research, fostering scientific entrepreneurialism and incorporating the teaching of enterprise into the higher education science and engineering curricula. A total of £28.9 million was allocated in 1999/2000 for 12 centres of enterprise across the UK, all based in universities through the SEC. This included the establishment of the Scottish Institute for Enterprise with £4 million. A second round of the competition was launched in April 2001, with an additional £15 million available to build on the success of the first round. In Scotland, enterprise education was incorporated within the primary school curriculum through the Schools Enterprise Programme. This was a joint venture partnership between the Scottish Executive and the business community. This programme offered every primary school pupil at least two entrepreneurial experiences by the end of their primary education. It involved a range of classroom activities designed to fit within the curriculum and help develop skills for the workplace. Key to its success was benchmarking of existing good practice through a series of showcase presentations (http://ec.europa.eu/enterprise/enterprise_policy/charter/2002).

The Higher Education Innovation Fund

The Higher Education Innovation Fund (HEIF) is a funding programme designed to encourage knowledge transfer in universities and other higher education institutions in England. It is the core mechanism for supporting knowledge transfer within the English higher education sector (devolved assemblies of Scotland Wales and Northern Ireland have their own support mechanisms). The HEIF supports institutions to engage in a broad range of knowledge transfer activities with business, public sector and community partners, for direct or indirect economic benefit. The HEIF is a partnership between the Office of Science and Innovation (OSI) and the Department for Education and Skills (DfES). The main objective of the HEIF is to foster research, development and technology transfer within academia, and to encourage and assist local universities to increase their capability and respond to the needs of businesses and the wider

community. The fund focuses on knowledge transfer from world-class research departments and centres of excellence to improve exploitation of the science base and release the potential social and economic benefits of UK universities (www.dti.gov.uk/science).

The Public Sector Research Establishment Fund

The aim of the Public Sector Research Establishment (PSRE) is to enable public sector research establishments to develop their capacity to exploit their science and technology potential and to provide seed funding to support the very early stages of business formation from ideas emerging out of research in the public sector science base. This fund was a response to the Baker Report, which was released in August 1999. This report emphasised the economic potential of public sector research establishments. The first round of awards, worth £10 million, was announced in October 2001. The second round of awards, worth £15 million, were announced in January 2004. The third round of awards, worth £25 million, was announced in January 2006(www.dti.gov.uk/science).

University Innovation Centres

The concept of University Innovation Centres is also utilised to promote innovations in the UK. For the purpose of this research report the researcher will refer to two centres to demonstrate how they are utilised to create innovations. These centres in Bath and Swindon provide hands-on support and expertise to new technology enterprises, and companies that emerge from the University's research base, established by academics and students (http://ec.europa.eu/enterprise/enterprise_policy/charter/2002).

From as early as the stage of exploring a novel business idea to the establishment of fully trading companies, the Innovation Centres provide support at each stage of a business's development. Through the pre-incubation facilities, and in the later-stage incubator area, Innovation Centre clients are offered fully serviced offices, opportunities to access finance, business skills mentoring and assistance with the protection of intellectual property (http://ec.europa.eu/enterprise/enterprise_policy/charter/2002).

A primary goal of the Innovation Centres is to encourage the development of new university companies and provide a route to market for spin-offs. Additionally, both centres host lively entrepreneurial communities that interact with the expertise and

research of the University's academics for mutual benefit. The Innovation Centre's management team offers new ventures, access to business know-how and university resources, business mentoring and appraisal, networking opportunities and competitively priced packages to encourage start-ups and entrepreneurs starting from £100 per month (http://ec.europa.eu/enterprise/enterprise_policy/charter/2002).

Other incentives include the R&D tax credit for SMEs, which is currently extended to large companies. This has also been complemented by the introduction of the Small Business Research Initiative to encourage SMEs to procure research contracts from government departments as well as research institutes. The UK S&T system also encourages universities to play a role in innovation, and therefore economic development, through the establishment of business clusters. To facilitate this process an amount of money has been allocated to establish University Innovation Centres, the Regional Innovation Fund as well as the Incubator Fund. This is meant to cement the role of universities in regional economic competitiveness (www.infoexport.gc.ca).

From the discussions above, it can be concluded that the UK S&T system has embraced changes brought about by globalisation. A number of legislative and policy reforms were introduced in the 1980s. Concerted effort has been made to prioritise research and technology innovations. A strong relationship between the business sector and academic institutions has been prioritised. This has led to the establishment of a close link between R&D initiatives and economic development. The University Challenge Fund is one of the successful initiatives in promoting technological research. Through the establishment of seed funds, it has created successful transformation of good research into good business. A number of projects have been supported through the seed funds. Other initiatives, such as the Innovation Centres, have been effective in encouraging the development of new university companies and have provided market access for university spin-offs. More importantly, the Innovation Centres have played a leading role in creating an enabling environment for the interaction of entrepreneurial communities with research expertise from academic institutions, which are mutually beneficial.

2.3.2 CANADA

Similarly to the UK, in Canada business leaders also worked closely with university and government leaders to implement changes in the tertiary education to contribute to

economic development (Slaughter and Leslie; 1999:52). Some changes were implemented when the Conservative Government took office in 1984. University and industry partnerships were developed in the early 1980s as a result of a search for alternative revenues by the higher education sector. This occurred after a decade of financial retrenchment in Canadian higher education, government policy statements and various scientific and research funding organisations shifted to a new direction for universities. This new direction adopted a corporate agenda advocated for a new era of co-operation between universities and the corporate sector which would be mutually beneficial to both. These growing linkages between corporations and universities in Canada transformed the structure and the mission of the university system, which gave the university an image of a corporation (BuchBinder and Newson; 1990).

This was done through the Corporate Higher Education Forum. This forum facilitated the creation of a techno science park, which was viewed as a generator for high-paying jobs as well as a player in the global market. Various projects to increase research were implemented in the early 1980s to encourage economic development through research and innovations. These projects included cost sharing between federal, provincial and local government. An example is the InnovAction programme, which is an agreement that was signed between these three spheres of government in 1987. Research parks and centres of excellence were also created in the 1980s to promote technology transfer from academic institutions to industry. The trend set in the 1980s of creating university-industry partnerships continued into the 1990s. Currently Canada's Federal Science and Technology Community encourages excellence in research, development and scientific services, and are taking concrete steps to achieve it. In enhancing its research, development and related scientific services, the federal government in particular encourages integration of efforts within and between departments and agencies of government, and between government's partners in universities, industry and foreign scientific institutions. A strong working relationship between industry and academic institutions continues to exist in Canada. Industry Canada is leading an interdepartmental working group on the promotion of scientific excellence. It builds on recommendations from the S&T Forum and the Council of Science and Technology Advisers (DST, 2005 DST, 2005).

One of the important bodies in Canada is the Canada Foundation for Innovation (CFI), which was established in 1997 by the federal government as non-profit organisation. Its aim is to strengthen the capacity of innovation incentives in Canadian universities, colleges, research hospitals, etc. to carry out world-class research and technology development. The initial budget to the CFI was \$800, which has subsequently increased to \$3.65 million. The Foundation uses this budget to fund and run various innovation incentives drives, as mentioned below:

- ❖ The Innovation Fund, which is meant to enable eligible institutions to strengthen their infrastructure in priority areas identified in their strategic research plans. Through this fund Canadian researchers are able to perform groundbreaking research.
- ❖ The New Initiatives Fund (NIF) seeks to support infrastructure initiatives in which the CFI has not previously invested and that enable institutions and their partners to develop their capacity in promising areas of research or technology development, as well as to improve their research competitiveness and international leadership. Through the NIF, the CFI challenges Canadian institutions to propose new infrastructure projects covering the full spectrum of research and development activities that will lead to breakthroughs and societal improvements for the benefit of Canadians.
- ❖ The Infrastructure Operating Fund (IOF) contributes to the incremental operating and maintenance costs associated with projects funded by the CFI to maximise the efficient utilisation of research infrastructure (www.innovation.ca/programs).
- ❖ The National Platforms Fund provides generic research infrastructure, resources, services and facilities that serve the needs of many research subjects and disciplines, and that require periodic reinvestments because of the nature of the technologies. The Fund has been established to fund high-performance computing infrastructure, and may prove to be the best vehicle to fund other types of generic infrastructure.
- ❖ The Exceptional Opportunities Fund: Although the nature of most infrastructure projects requires significant time from conceptualisation to implementation, there may be some instances where an exceptional research opportunity would be missed if a project had to wait the normal time period of a national competition before a decision is made. It is in this context that a need for a rapid response

- mechanism has been created that will further assist institutions and their partners to participate in unique opportunities for exceptional and innovative research enabled by infrastructure.
- ❖ The Leaders Opportunity Fund (LOF) builds on the New Opportunities Fund, the Canada Research Chairs Infrastructure Fund and Career Awards Fund, and is designed to assist universities in attracting excellent faculty to Canadian universities as well as retaining the very best of leading researchers for Canada.
 - ❖ The International Joint Venture Project 2005: In 2002, the CFI invested about \$165 million in nine projects, comprising three joint venture and six international access projects, to help Canadian institutions lead and participate in major multi-national projects. There is \$35 million remaining to fund a fourth international joint venture project. The international Joint Venture Fund seeks to support a joint collaborative research venture between one or more leading Canadian institutions, and at least one leading institution located outside Canada. It is meant to encourage collaboration between the best institutions in Canada and the best institutions in the world. This initiative is an attempt to ensure that Canada is the leader in specific research areas such as biotechnology. It is also meant to demonstrate existing collaborative initiatives as well as potential research initiatives. The Career Awards is meant to recognise and support outstanding researchers by providing the required infrastructure to the institutions to carry out research programmes (www.innovation.ca/programs).

Canada is one of the leading countries in terms of research funding and outputs such as publications. According to King (2004), Canada ranks at number three after the UK and the United States of America (USA) (King; 2004). This can be attributed to the number of investments that support innovations at the academic level and the support provided to link research activities in academic institutions to industry.

2.3.3 FINLAND

In Finland there is general acknowledgement that S&T is critical for economic development (www.hightechfinland.com). To achieve this, the Finnish government encourages innovation through national technology development programmes as well as science parks. The concept of science parks works well in Finland, where universities and industry work together to generate new innovations for the markets. These

innovations encompass ICT, biotechnology, materials and processes, etc. The science parks draw on a strong local research base and also provide home units to companies such as Nokia, Ericson and Siemens. The parks also emphasise interdisciplinary synergy (www.hightechfinland.com).

Science and Technology governance in Finland

Science policy is the responsibility of the Ministry of Education. Finland has a dedicated institution dealing with research funding called the Academy of Finland. Publicly-funded research is mainly conducted in universities and research institutes. Finnish technology policy is designed to strengthen the competitiveness of technology-based enterprises. It is designed to ensure positive development in science and scholarship. The aim is to raise the level, ensure the comprehensiveness, enhance the social impact and promote the international penetration of Finnish research. Technological progress is used to create new business opportunities and promote the growth of existing business. Technology policy is therefore a central component in industrial policy (www.hightechfinland.com).

The Science and Technology Policy Council of Finland, chaired by the Prime Minister, advises the government and its ministries on S&T-related issues. The Council is responsible for the strategic development and co-ordination of Finnish science and technology policy as well as the national innovation system as a whole. The membership consists of the Minister of Education and Science, the Minister of Trade and Industry, the Minister of Finance, and some other ministers. In addition to them, the membership includes ten other members well versed in S&T. These members must include representatives of the Academy of Finland, the National Technology Agency of Finland, universities and industry as well as employers' and employees' organisations. The Council of State appoints the members for a three-year term. The Council has an executive committee, a science policy subcommittee and a technology policy subcommittee with preparatory tasks. These are chaired by the Minister of Education and Science and the Minister of Trade and Industry, respectively. The Council's secretariat consists of two full-time chief planning officers. They are appointed by the Council for a three-year term (www.minedu.fi).

Innovation incentives in Finland

In 2002 the Finnish Technology Award Foundation was established to promote scientific research aimed at developing new technology to improve Finnish competitiveness as well as the quality of lives of the Finnish people. It also administers the Millennium Technology Prize. Awards are given for achievements in energy and environment, communication and information, new materials and processes as well as health care and life sciences. The prizes are awarded to individuals as well as teams who have contributed to the innovation. Nominations are accepted from universities, research institutions, national academies of science and engineering, etc (www.minedu.fi).

The Academy of Finland provides funding for high-quality scientific research, serves as an expert organisation in science and science policy, and strengthens the position of science and research. Annually, the Academy issues funding worth around 200 million Euros. More than 3 000 research professionals are involved in Academy-funded projects at universities and research institutes. Academy research funding is designed to promote gender equality and specifically to encourage women to apply for research posts and research grants. The Academy of Finland has a range of different funding instruments designed to advance professional careers in research. It provides funding for research projects, research programmes, centres of excellence in research, researcher training, international co-operation as well as research posts for Academy professors and Academy research fellows. The Academy has four research councils that decide on the allocation of funding within their respective fields (www.aka.fi). The councils cater for the different stages of research career, namely:

- Researcher training stage.
- Postdoctoral research stage.
- Gaining independence and established researcher stage.

The following are the priorities of the policy:

- To effect a substantial increase in research funding and maintain the GDP share of R&D at a world top level. The additional funding will be allocated to strengthen basic research, researcher training and research infrastructure, to promote research careers and to boost social innovation.
- To step up the development of centres of excellence.
- To promote national, European and international networking in research.

- To make use of European Union (EU) research programmes, other international research schemes and bilateral arrangements.
- To support research especially in fields relevant to knowledge-intensive industries and services, such as biotechnology.
- To intensify co-operation between the users of the research system and research findings and the diffusion of research findings.
- To promote the commercialisation of research findings and the creation of new business and the utilisation of research findings and technology.
- To provide input on impact analysis and the evaluation of the state and performance of the research system (www.aka.fi).

Another important source of funding in Finland is Sitra, the Finnish National Fund for Research and Development. Sitra is an independent public foundation under the supervision of the Finnish parliament, with a mandate to promote the economic prosperity of the Finnish people. Sitra's aim is to establish and develop Finnish enterprises that are internationally competitive and profitable. Sitra is able to offer such companies both development and funding services. The focus is on companies that are at an early stage of their existence. Sitra targets its capital investments at the fields represented in the programmes launched in autumn 2004. Among its areas of focus, it also focuses on its new role of venture capital operations, specifically on pre-seed and seed phases, to optimise efficiency and returns. This involves developing and experimenting with new funding models and adapting them to public and private sector operations. Growth phase investments are limited. Sitra co-operates with both private investors and public sector bodies such as the National Technology Agency (Tekes), Finnish Industry Investment Ltd, Finnvera, Finpro, the Academy of Finland, the Employment and Economic Development Centres (TE centres) and the Foundation for Finnish Inventions (Keksintösäätiö). In addition to its funding activities Sitra closely monitors venture capital investment both in Finland and on international markets. Sitra also helps to develop this market (Finland Competitive Innovation Environment Development Programme).

According to a survey conducted by Meyer (2004), the incentives and funding mechanisms to academic institutions and entrepreneurs have influenced the increase of patents (Meyer, 2004:2-17). Most patented inventions of Finnish academic researchers

are utilised by large and established small- and medium-sized firms rather than by academic and start-up companies. This applies to inventions exclusively by academics as well as inventions by academics and industry. The invention trends reflect that the purely academic inventions occur in the field of life sciences and in the technology areas of pharmaceuticals, chemicals and biotechnology. Inventions between industry and academia occur in the fields of engineering fields as well as life sciences. Commercialisation of academic inventions in start-up companies is above the expected value in life sciences and below the expected value in engineering and materials science. This could be due to lack of demand for technologies developed in the engineering field. These inventions still find commercial application in large firms rather than in new start-up ventures or SMEs. Some university inventions are mainly utilised by large firms, while other universities specialise in inventions that are used by start-up companies (Meyer, 2004:2-17).

Finland is one of the world's best performers in terms of R&D indicators. According to Statistics Finland, the GDP share of R&D expenditure was 3.45% in 2006. This figure has recorded growth for the fourth successive year (Statistics Finland: 2006/2007). This can be attributed to a combination of factors, such as the existence of a sound S&T system and policies, adequate infrastructure for S&T initiatives and suitable research priorities. These factors, as shown in the discussions, are coupled with appropriate funding models to enhance research and technology development in Finland. It is important to note that the incentives schemes and funding options have led to increased patents. However, most of these patents are consumed by existing large and small- to medium-sized companies, contrary to the perception that similar consumption patents will be expected from the academic and start-up companies. The explanation for this development may be worth investigating.

2.3.4 BRAZIL

Brazil is the most technologically developed country in Latin America. It accounts for almost 50% of the region's total R&D expenditure. The S&T system focuses on incubation, which represents a new direction in science, technology and industrial policy. The incubator movement in Brazil started after the collapse of the military regime and the renewal of civil society in the 1980s. The 1982 elections led to academics

participating in policy formulation and the government being receptive to academics as they filled in top government positions. Large cities such as Rio de Janeiro developed their own S&T departments. This led to collaboration between the different spheres of government. The incubator movement allowed Brazil to create a less costly development model, taking advantage of the existing academic, industrial and government resources. Universities play an expanded role in the Brazilian national system of innovation. There are currently 237 incubators in Brazil, 107 of them are technology-based companies, 56 are companies from traditional economic sectors, 40 are mixed technology and traditional economic companies, 29 are co-operatives and 5 are private (Etzkowitz et al, 2005:412). Brazil offers five different types of tax incentives for R&D. Brazil has three types of research grants and loans administered by two different government agencies. With regard to venture capital, Brazil has the INOVAR project, although this is in its initial stage. INOVAR was initiated to stimulate the development of new technology-based companies through the establishment of a venture capital market and to enhance private investment in technology business. It has a technology investment facility, which funds small technology-based initiatives. It was launched in May 2000 to assist SMEs who have no track record, no collaterals or no cash flow (Etzkowitz et al, 2005:412).

Although there has been a reduction in loans and grants in Brazil, there has been a significant increase in tax incentives. Tax incentives have been effective in increasing R&D investments by enterprise. Human resource development in the field of S&T has also been encouraged. However, due to low demand for scientists in Brazil, there is very low density of scientists and engineers. On non-fiscal instruments, Brazil is strengthening the technological infrastructure by reforming government research institutes (GRIs) (www.florababrazil.com).

The government of Brazil intervenes in technology development in many ways. One of these ways is through the partnerships between academic institutions, private companies and research institutions (Ekboir, 2003:573-575). One of the prominent institutions involved in technology transfer is the Disque Tecnologia based at the University of São Paulo. Willingness of the universities to participate in R&D activities is shown by the formation of special research institutes to deal with technology transfer. These include the Computer Science Department of the University of Rio, which has participated in many innovative initiatives with the private sector (Dornelas et al; 2-7).

Various measures have been implemented in Brazil to create a conducive environment for technological innovation. These measures include incentives aimed at encouraging companies to be innovative. Tax rebates are given to companies who invest 5% of their revenue in R&D. At least 2% of this should be invested in joint projects with universities and research centres or in priority programmes defined by the Ministry for Science and Technology. The fiscal incentives include a rebate of up to 50% of the income tax in a fiscal year with expenses in R&D and exemption of the industrialised product tax upon purchases of machines and equipment produced in the country to be employed in R&D projects. More than 250 companies have benefited from these incentives with a total amount of approximately 250 million dollars a year (Dornelas et al; 2-7). However, it is important to note that fiscal incentives that refer to income tax benefit only those companies that are profitable. These are not necessarily those that put most effort into R&D. Therefore income tax incentives have limited effect (Meyer-Stamer, 1995:4).

The contradictions that exist between the S&T and economic policies impact negatively on innovations. The S&T policy aims at increasing technological autonomy in Brazilian companies, while the economic policy encourages a free entry of foreign capital, including the import of foreign technologies to increase their competitiveness, which provided short-cuts for companies to avoid the costs of R&D (Sbragia et al, 2002:5-6). For the big firms there is an inclination to duplicate what already exists and for the small firms a lack of resources and technical know-how may lead to poor innovation and university-industry linkages. Table 4 below illustrates poor interactions between companies, technological institutes and universities. In total, 108 companies that carry out co-operative projects with other external institutions have been analysed. The figures show that the trend of the companies analysed to develop co-operative projects with universities/technological institutes grew consistently over the five years of the study, in all institutions, namely universities, technological institutes, other companies and, in some years, engineering/consultancy companies (Sbragia et al,2002:8).

Table2.1: Interactions among companies, technological institutes and universities

(Source ANPEI Database Elaboration 2002)

Indicators	1996	1997	1998	1999	2000
Universities	25	29	36	38	45
Technological institutes	19	20	29	34	35
Engineering/consultancy companies	25	23	32	39	35
Other companies	15	12	19	19	21
Total number of partnerships	84	84	116	130	136

Brazil's performance compared to other countries in technological innovation measured by patents is relatively low. When compared to the developed countries such as the USA and Japan, technology transfer in Brazil is still at the infancy stage. This is shown by the small number of patents registered by Brazilian companies compared to the developed countries. In 1991 USA/Canada had 48% of the American patents, Japan 25%, the European community 24%, Korea/Taiwan/China 1.5%, Israel/Australia/New Zealand 1% while the remaining countries including Russia and India received approximately 0.5%. Out of the 1% of the US patents received by the countries with first world science (advanced S&T system in terms of R%D indicators); (Russia and India,) Brazil received 10% of those patents. Publications from the Brazilian scientists are higher than patents. This means that the highest R&D outputs come from publications rather than patents. This can be used as a basis for improvement because a strong science base is supposed to create a strong technology base (Sbragia et al, 2002:5).

INNOVATION INCENTIVES IN BRAZIL

Brazil has a number of innovation incentives aimed at creating a conducive environment for innovations to prosper. One of these initiatives is called the programme for technological development (MCT). This programme was created in 1984 to encourage technological innovations in priority areas. The programme is jointly funded by the World Bank and the Brazilian federal government (Sbragia et al, 2002:5). It focuses on applied research and encourages private sector investment in R&D projects. Technology gaps in

specified priority sectors are identified through consortia and actions to bridge the gaps are implemented.

The FAPESP (Fundação de Amparo à Pesquisa do Estado de São Paulo) Programme was created in the 1990s to implement special programmes such as the Programme of Partnership for Technological Innovation (PITE) and the Programme of Technological Innovation in Small Companies (PIPE). PITE started in 1994 to fund innovative projects in the productive sector, in partnership with the research institutions and private companies from the state of São Paulo. PIPE, on the other hand, finances research aimed at technological innovation directly in the companies. This programme only focuses on small companies with less than 100 employees, and the researcher leading the project can either be employed by the company or indirectly related to the company.

The SOFTEX Programme was introduced in 1993 to change the focus in the IT sector from innovations in hardware to innovations in software. This programme supports entrepreneurial activities associated with software development by introducing courses at universities related to the generation of new software companies. Students in the Faculty of Computer Science are therefore encouraged to generate start-up companies and are given support such as infrastructure and use of laboratory facilities, software development tools, technical support, managerial seed money and grants for attending fairs and other events both locally and internationally (Sbragia et al, 2002:5).

The RHAE Programme (Programa de Capacitação de Recursos Humanos para Atividades Estratégicas): This is an initiative of the Ministry of Science and Technology to improve the competitiveness of national companies in the world market through human resources development. This programme provides grants for the training of personnel, especially those associated with technology-based companies at universities and research institutes and those involved in partnerships. In addition to the specific programmes, awards are also given to individuals and/or institutions that contribute with outstanding technological innovation, such as the Alcatel prize for innovation in information technology (Sbragia et a, 2002; 6).

The strong role played by academic institutions in technology transfer has been evident in Brazil. There is also a trend of using international financial institutions such as the

World Bank, the Inter-American Development Bank and the United Nations Development Plan (UNDP) to co-fund the research and innovation projects with the Brazilian government(Sbragia et a, 2002;6).

In Brazil the success stories of innovation incentives can be traced to the various sectors of the economy. In the agricultural sector, an increase in the growth of agricultural production started in the 1970s with the shift from a base in the expansion of cultivated land to one driven by increased yields, and the introduction of new crops and of new varieties of traditional ones. This happened mainly through providing incentives in public research. To enhance public research, EMBRAPA, which is a public sector corporation responsible for co-ordinating R&D activities in the field of agriculture with institutions such as universities, private enterprises, and a number of national, regional, and state-level research institutes, was created in 1972. The incentives encourage research carried out at regional or state centres to focus on local production systems. This research also aims at adapting to local conditions the result of research conducted at national centres. It should be noted that EMBRAPA plays an important role in the linkages between the Brazilian system of agricultural innovation and foreign research centres, with whom it engages in co-operative research activities (Dahlman and Frischtak, 1993).

Of equal importance is the role that incentives provided through the higher education and public research institutions play in the successful development of specific industrial sectors. In particular, the origins of Embraer, which is currently the world's fourth largest aircraft vendor, illustrate important aspects of the relationship between education, research and the development of technological capabilities. In a quest to develop the aerospace industry, Brazil established the Centro Tecnológico da Aeronáutica (CTA) in 1945. This centre is responsible for co-ordinating the activities of an engineering school and a research institute. Overseas institutions provided both a model for the centre and a share of the initial faculty and research personnel at CTA. The engineering school (Instituto Tecnológico da Aeronáutica or ITA) was organised in co-operation with MIT, and during the early years of activity a number of leading academics came to ITA from MIT and other international institutions. Most importantly, this co-operation between the two institutions provided an opportunity for ITA students to get international exposure through studying and conducting research abroad. The successful launch of various undergraduate degree programmes as well as a graduate engineering school is linked to

the creation of a demand for engineers at research institutes located at CTA, and particularly at Embraer, which is a government-owned company. This company was established in 1969 to develop aircraft based on Brazilian design and engineering (Dahlman and Frischtak, 1993).

Access to engineering talent from ITA and R&D activities conducted at the research institutes of CTA played a crucial role in the success of Embraer. This had a positive impact in the growth of a cluster of technologically sophisticated enterprises located in Sao Jose do Campos. As a result of the public investments in training and research carried out during the 1950s and 1960s, Embraer accumulated technological capabilities in aircraft design and manufacturing. Embraer emphasised the significance of joint development projects and technical co-operation with foreign enterprises. Effectiveness in this learning process enabled Embraer to reach the level of being the best internationally in the development of aircraft development projects. These developments occurred mainly as a result of the two-pronged public investment in training and research carried out by the CTA (Dahlman and Frischtak, 1993).

The government of Brazil has also made an effort to deliberately avoid provision of support on the basis of possible success of commercial products only. Support was channelled towards the identification of broad economic sectors and technologies where public research can be productive. Programmes that have been supported include support of agricultural research and health. With regard to agricultural research, the focus has been on the particular problems and opportunities of indigenous agriculture. Other research programmes in Brazil have encouraged the development of indigenous capabilities in manufacturing. These are technologies that encouraged indigenous firms to be effective in being innovative. Brazil's programme in aviation technology was designed to enable domestic capabilities to become international best players (Dahlman and Frischtak, 1993).

The above example from Brazil shows that incentives encourage innovativeness and sharing of risk. These incentives are structured in such a way that risks and rewards are shared between the innovators, the government that provides funding and the research institutions. These incentives are also structured to help emerging entrepreneurs with management techniques, advice and experience and to encourage an entrepreneurial mentality. They also provide investment in the form of financial backup to enable the

transition from promising research work to commercial reality. This encourages companies to produce high-quality S&T, combined with professional management teams to produce investor-ready and partner-ready opportunities (Dahlman and Frischtak, 1993).

2.4 CONCLUSION

This chapter has examined the growing trend of innovation incentives as a tool to stimulate innovations, particularly among academic institutions. The researcher has demonstrated that a number of innovation incentives are utilised to promote innovations. It has been established that all the countries have considered a good combination of sensible S&T systems and S&T policies. This is regarded as a cornerstone for governments to create an enabling environment for technology innovations.

It was illustrated in this chapter that efforts have been made to promote strong relationships between academic institutions and industry.

The researcher has demonstrated that there is a positive relationship between the incentive schemes and technology innovations as measured by indicators such as patents. There are positive results of using these incentives, which have led to increased innovations as measured by the number of patents. However, although there are many general instruments to encourage academic entrepreneurialism, there are few innovation competitions. It may be worth exploring the reasons for the existence of few innovation incentives.

Chapter 3

THE SCIENCE AND TECHNOLOGY LANDSCAPE IN SOUTH AFRICA

3.1 INTRODUCTION

This chapter focuses on the S&T landscape in South Africa by giving a brief overview of the S&T system. The purpose of this overview of the S&T landscape is to provide a context in which academic entrepreneurship operates in South Africa. This chapter demonstrates the links between historical developments and the current challenges facing the S&T system. It also provides a detailed outline of the current S&T system and demonstrates the relevance of S&T in the South African society. This is done through outlining the key legislative frameworks in South Africa and how these link up with the specific S&T policies. The relevance of S&T in addressing national imperatives is demonstrated through a brief outline of key policy instruments in the S&T system, namely the IF and the NIC. These instruments are central in addressing some of the challenges in the NSI. Specific focus is placed on the NIC, as it addresses the challenge of low levels of innovation within the higher education sector. As shown in the previous chapter, this challenge is not unique to South Africa (Innovation Fund Business Plan, 2005/2006).

3.2 SCIENCE AND TECHNOLOGY HISTORY IN SOUTH AFRICA

The South African S&T system has a long history, dating from as far back as 1751 (Cenis, 2000:3-42). It has developed over the years and has served different political and ideological interests. Like all spheres of the South African society, the S&T system was affected by political, economic, cultural and scientific isolation imposed by the international community as a punitive measure against racial segregation policies (Cenis, 2000:3-42). In the S&T sector, isolation was in the form of lack of scientific contact with international partners. This included limited participation in scientific conferences, few publications in international journals and generally very little international scientific collaboration especially in such fields as the humanities and social sciences (Mouton, 2003:243). The impact of isolation was felt at different levels within the South African S&T system. The years of isolation contributed to the current challenges in S&T, which the democratic government is still grappling with.

As a result of isolation, the S&T system in South Africa still lags behind its international partners, as evidenced by the 2005/2006 R&D survey results. During this period, South Africa spent approximately R14 149.2 billion, which is equivalent to 0.92% of the GDP, on R&D. This is an improvement from the 0.69% of GDP that was recorded in the 1997/1998 survey. In comparison with the OECD countries, South Africa spends relatively little on R&D. This trend is similar for most developing countries, as illustrated by Figure 3 below. In 2005 the USA spent \$324.5 billion on R&D and Japan spent approximately \$130.7 billion on R&D, which is about 60% of the \$772 billion OECD total (see Figure 3 below). The average annual R&D growth rate of nine non-OECD economies, namely Argentina, China, Israel, Romania, the Russian Federation, Singapore, Slovenia, the Republic of South Africa and Taiwan was about 15.5% between 1995 and 2005(www.nsf.gov/statistics).

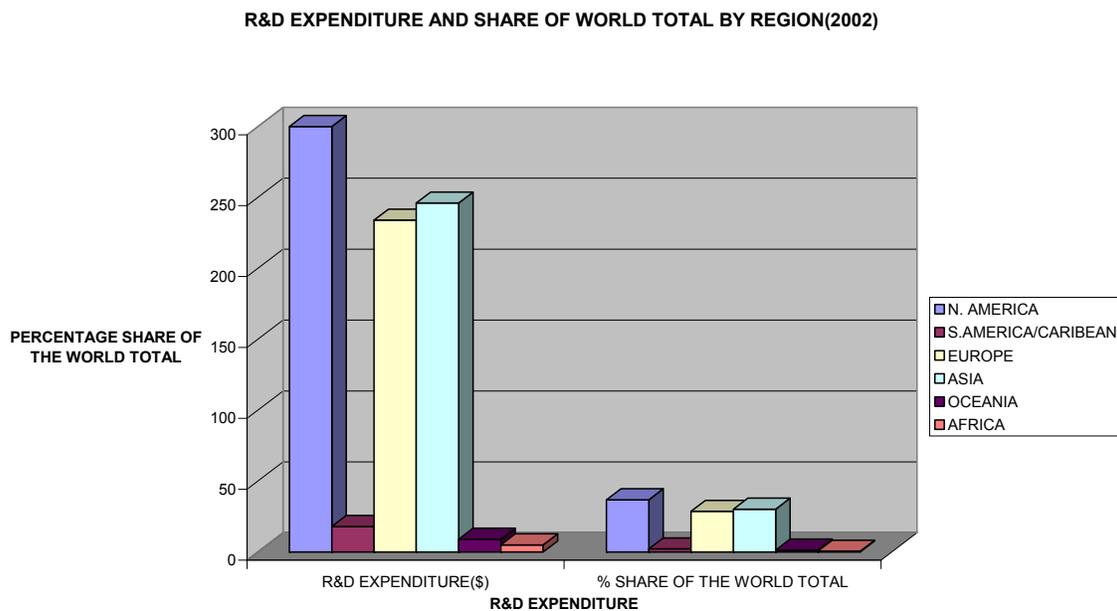


Figure 3.1: R&D expenditure and percentage share of world total by region (2002)

This poor performance in scientific and technological activities can be attributed to a lack of international competitiveness, a lack of benchmarking with international partners as well as a lack of exposure to the latest S&T discoveries internationally. The South

African S&T professionals were denied access to international standards for benchmarking. The development and design of the system was tailor-made to serve the interests of the apartheid regime. These include the need to be self-sufficient in order to avoid dependency on the international community (Cenis, 2000:43). The S&T system played a major role in making the apartheid regime self-sufficient, thereby reducing the impact of isolation. Regardless of isolation, the S&T system recorded strengths in certain fields such as agricultural sciences, mining technologies as well as defence technologies. There is evidence that the South African S&T system continues to be strong in areas involving its natural wealth and biodiversity. These range from ecology and environmental sciences, geosciences, plant and animal sciences and space science (astronomy) as reflected in the publication records of the Thompson Institute for Scientific Information (ISI) (South African Journal of Science, 2003:99).

The higher education sector is an important player in the production of new knowledge within the S&T system. This sector was fragmented between Afrikaans- and English-medium institutions on the one hand and the ethnic-based universities on the other hand. The ethnic-based universities were created from the 1960s, and include universities such as the universities of Zululand, Venda and Transkei. The segregation of academic institutions created polarisation and general inequalities within the higher education system. Academics interacted and collaborated along ideological lines. The Afrikaans institutions worked together, while the more liberal institutions worked together. In terms of funding, the more liberal institutions refused to apply for funding from the apartheid regime. There was also polarisation between privileged white universities and disadvantaged black universities. Although various measures have been introduced to deal with these inequalities after 1994, the higher education sector is still grappling with these realities (Cenis, 2000). The polarisation in the higher education sector had an impact on R&D conducted by these institutions. Currently the historically black universities produce fewer publications compared to their white counterparts. Sixty per cent of the publications are from five previously white institutions namely UCT, UKZN, University of Pretoria, Stellenbosch and Witwatersrand (Mouton and Boshoff, 2003:218).

Other challenges faced by the HEIs include the government funding model for research, which is skewed towards applied research. The fact that there are financial rewards

attached to these activities, with teaching and basic research are viewed as less financially rewarding than applied research, worsens the situation. This and the huge growth in student numbers over the past ten years often force academic staff to focus on teaching instead of performing innovation activities. Another issue for consideration relates to the fact that research may lead to better teaching but the inverse does not apply (CHET Report, 2003:6).

When the democratically elected government took office in 1994, it had to deal with, among other things, the fragmentation of the S&T system, the polarisation of the academic institutions, low research and development outputs as well as human resource development in S&T. To address these problems, the democratic government introduced institutional and policy reforms to create an enabling environment for S&T to support national imperatives such as improvement of the quality of life, economic growth and competitiveness.

Based on the brief historical background of S&T in South Africa, it is evident that the years of isolation created a strain on the system. Under the apartheid system South African science “developed one of the most sophisticated nuclear and defence R&D industries in the world, a vibrant energy research industry as well as other internationally competitive research niches, but on the other hand could not provide shelter, clean water or basic services to the majority of its population”(Mouton, 2004:11). It is against this background that it is argued that the S&T system did not cater for the needs of all South Africans. Resource allocation was also skewed in favour of certain institutions and sections of society (Mouton, 2003:243). Despite this strain, the S&T system did not collapse. Instead, the years of isolation laid a solid foundation for the system to be strong in scientific fields related to South Africa’s natural wealth, as recorded in the ISI database. However, because of a lack of international collaboration during the years of isolation, South Africa remained weak in certain fields such as engineering and applied physics (Pouris, 2003:425).

3.3 SCIENCE AND TECHNOLOGY GOVERNANCE IN SOUTH AFRICA

During the apartheid era S&T was housed in the National Department of Education, which dealt with education and training at school level as well as higher education. The Research and Development Directorate in the higher education sector was also housed under the National Department of Education (Cenis, 2000:43).. After 1994, the Department of Arts, Culture, Science and Technology (DACST) was created. S&T was a branch within DACST, responsible for policy formulation, policy implementation, creation of an enabling environment for S&T as well as promotion of S&T both locally and internationally. Due to the focus on new national imperatives as well as the realisation of the role that S&T plays in economic development, the prominence of S&T has grown tremendously in the past ten years. As a result of the growing prominence, in August 2002, a separate director general was appointed to oversee S&T matters only. In that way the DST was established as a fully fledged department, although the department still reported to the ministry of DACST. This was followed by the appointment of a new minister responsible for S&T in April 2004. The role of S&T in achieving national imperatives is articulated in the mission of DST, namely to develop, co-ordinate and manage a national system of innovation that will bring about maximum human capital, sustainable economic growth and improved quality of life for all. The DST vision is to create a prosperous society that derives enduring and equitable benefits from S&T (DST Corporate Strategy, 2002-2005).

In carrying out its mandate, the DST acknowledges and works closely with partners in the NSI. These partners include science councils, academic institutions, private companies such as SASOL and state-owned companies such Denel and Armscor. These institutions contribute a significant amount of resources to R&D. Within the government structures, the DST's partners include the Department of Communications, the National Department of Agriculture, the Department of Education, the Department of Minerals and Energy as well as the Department of Trade and Industry. These departments play an important role in the S&T landscape of South Africa.

At cabinet level, a Ministers' Committee on Science and Technology (MCST) was formed, which consists of all ministers whose responsibilities include a significant S&T component. The Committee's main function is policy co-ordination and information dissemination for S&T matters across government. The secretariat of MCST is hosted by

the Department of Science and Technology. Participating departments include Trade and Industry, Minerals and Energy, Health, Agriculture, Transport as well as Defence. At the level of Parliament, there are two committees that oversee S&T policy matters, namely the Committee on S&T of the National Assembly and the Select Committee on S&T of the National Council of Provinces. The Select Committee also handles other portfolios such as Arts and Culture (Cenis, 2000:52)..Figure 4 below is a structural representation of co-ordination of the S&T system at government level (Cenis, 2001:5).

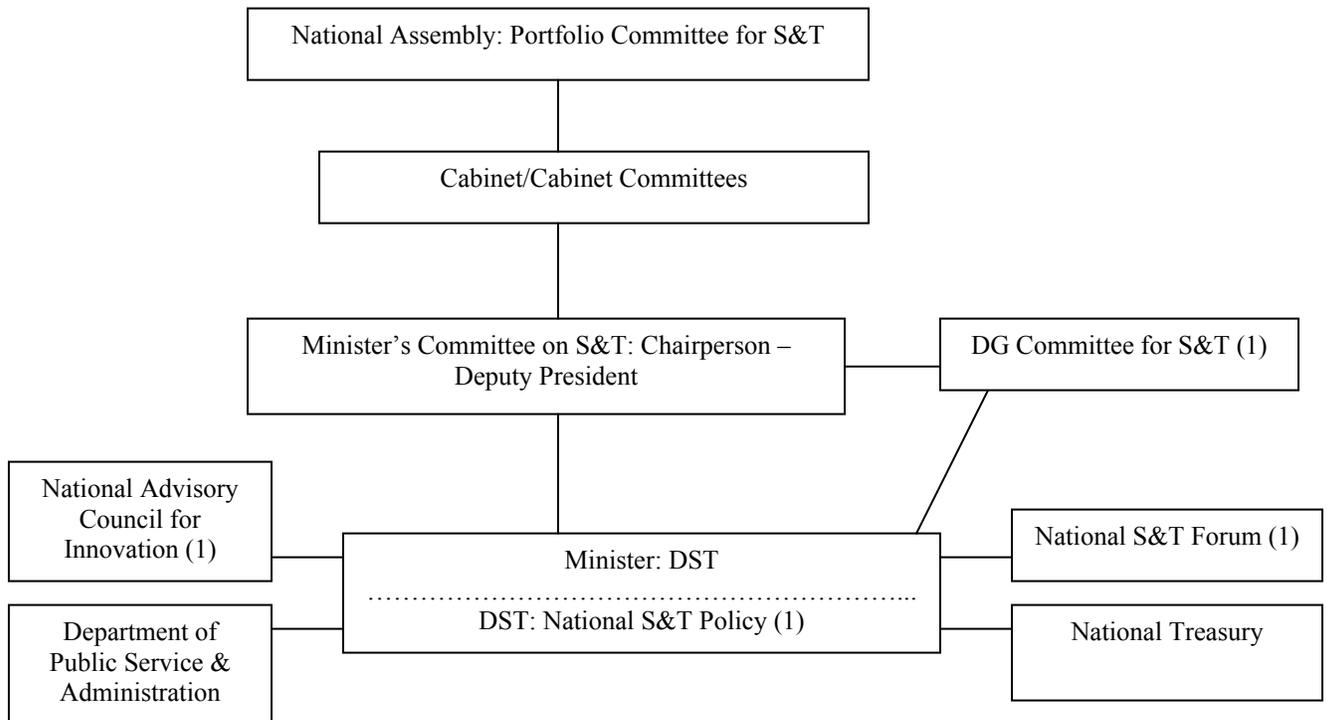


Figure 3.2: Governance structure of the South African Science and Technology system

The creation of a separate DST is viewed as a commitment by government to promote S&T in support of the national imperatives. This commitment is strengthened by supporting institutions and the oversight committees. In addition, additional and increasing amounts of resources are allocated to achieve these objectives, as outlined in the S&T policy framework.

3.4 GOVERNMENT POLICY FRAMEWORK

After 1994, the government introduced the Reconstruction and Development Programme (RDP), which was meant to redress the imbalances of the past. The principles of the RDP ranged from integrated and sustainable development (which includes resource mobilisation), peace and security, nation building, provision of basic services (including infrastructure), human resource development, as well as democratising the South African society (www.polity.org.za/govdocs/rdp4). Although there is a view that the RDP has failed, some successes were recorded. These include the provision of free health care for pregnant women and children and the provision of food for under-privileged school children. In the area of housing delivery, the RDP has been criticised for failing to provide the envisaged number of houses as well as for poor quality in service delivery. Although these criticisms are valid, it should be recognised that progress has been made in the provision of services. It should also be accepted that a lot of improvement is required in the quality of service delivery.

In 1996 the government adopted a new policy framework known as the Growth, Employment and Redistribution Strategy (GEAR). This was viewed by some sectors as an abandonment of the RDP and the principle of redressing the imbalances of the past. However, GEAR captured some RDP principles such as the provision of basic needs, human resource development and democratisation of the society. In addition, GEAR advocates for a neo-liberal macroeconomic policy, an outward directed and competitive economy, fiscal and monetary discipline as well as job creation. These are viewed as necessary elements for achieving economic growth and international competitiveness. GEAR has set a target of 6% growth rate per annum. In order to achieve the proposed growth rate GEAR proposes various measures such as privatisation, rightsizing of the public sector, relaxation of exchange controls, flexibility of labour market regulations as well as job creation and capacity building (Department of Finance, 1996).

It can be argued that the RDP and GEAR have some common principles. However, GEAR focuses on principles related to economic competitiveness. The approach to economic competitiveness envisaged in GEAR does not necessarily satisfy all South African interests, particularly the working class interests. The dispute caused by the GEAR principles has caused major tensions between the African National Congress (ANC) and its alliance partners. Efforts to resolve these tensions through structures such

as NEDLAC have encouraged debate on these issues, but have failed to resolve the tensions. Supporters of GEAR argue that although it has failed to achieve the envisaged 6% economic growth, it has succeeded in creating a stable and growing economy. The unions, on the other hand, argue that the recorded economic growth has not translated into significant job opportunities and a reduction in unemployment.

The latest development in the South African economic policy landscape is the introduction of the Accelerated Shared Growth Initiative of South Africa (ASGISA), which is championed by the Deputy President of the Republic of South Africa. ASGISA has emerged at a time when the South African economy recorded an average economic growth of 3.2% per year over the past four years. The economy has also achieved a sound macroeconomic environment. The main objective of ASGISA is to tackle socioeconomic challenges facing the country. To achieve this objective, economic growth has to reach 6%, as stipulated in the Millennium Development Goals. ASGISA seeks to achieve an annual economic growth rate of 4.5% or higher between 2005 and 2009. Between 2010 and 2014 ASGISA seeks to achieve a growth rate of least 6%, as envisaged in GEAR. Key areas of focus for ASGISA include macroeconomic policy, infrastructure development, sector investment strategies, second economy interventions and public administration issues. It also emphasises the role of social partners such as labour, civil society and business in tackling socioeconomic challenges (State of the Nation Address, 03/02/2006). The overall expenditure for infrastructure is R370 billion for the current Medium Term Expenditure Framework. This amount is allocated accordingly to different critical interventions required for the success of ASGISA (Parliamentary Media Briefing; 06/02/2006).

It is worth noting that in the last decade in South Africa three major policy initiatives have been introduced and implemented, namely the RDP, GEAR and now recently ASGISA. All these policy frameworks are meant to guide interventions in critical areas such as poverty alleviation and improvement of quality of life. Although some successes have been recorded with the implementation of the RDP and GEAR, one hopes that the failures of the past will not be repeated in the implementation of ASGISA. Once weaknesses have been identified in these policies, new policies have been introduced and implemented. Attempts to rectify weaknesses are unclear. It can be argued that the change of policies within a short space of time has not allowed adequate time for

implementation. It is against this background that it is hoped that with ASGISA monitoring mechanisms will be developed that will detect problems areas soon enough to allow them to be corrected.

3.5 SCIENCE AND TECHNOLOGY POLICY FRAMEWORK

3.5.1 THE WHITE PAPER ON SCIENCE AND TECHNOLOGY

When the democratic government took office in 1994, it inherited an S&T system that was fragmented and not geared to serve the interests of all South Africans. The R&D spending priorities shifted from the previous technology missions that were implemented by the Nationalist Party government. Missions such as military dominance in the subcontinent, energy efficiency and food security were terminated to focus more on R&D activities that would lead to economic and social benefits. The percentage of the South African Gross National Product (GNP) expenditure on R&D declined from 1.1% in 1990 to 0.7% in 1994. The NSI is facing a challenge of frozen demographics, i.e. aging personnel within the system, which does not represent the demographics of the country (DST R&D Strategy, 2002:20-23). Figure 5 below (from CENIS later changed to CREST; the SA Knowledgebase) is a reflection of the age profile of the scientific and research community in South Africa during the period 1990–2000. It should be noted that the data represents publishing researchers (mostly academics) and not all researchers in the country such as researchers employed in the business sector. This diagram shows that the majority of the publications are from the age groups 50–59 and 60+. The publications from the age groups 30–39 and 40–49 have shown a decrease during this period. This is a concern within the NSI because the most active researchers are approaching the stage of retirement and there is no mechanism for increasing publications from the younger generation, which is supposed to be actively involved in producing publications.

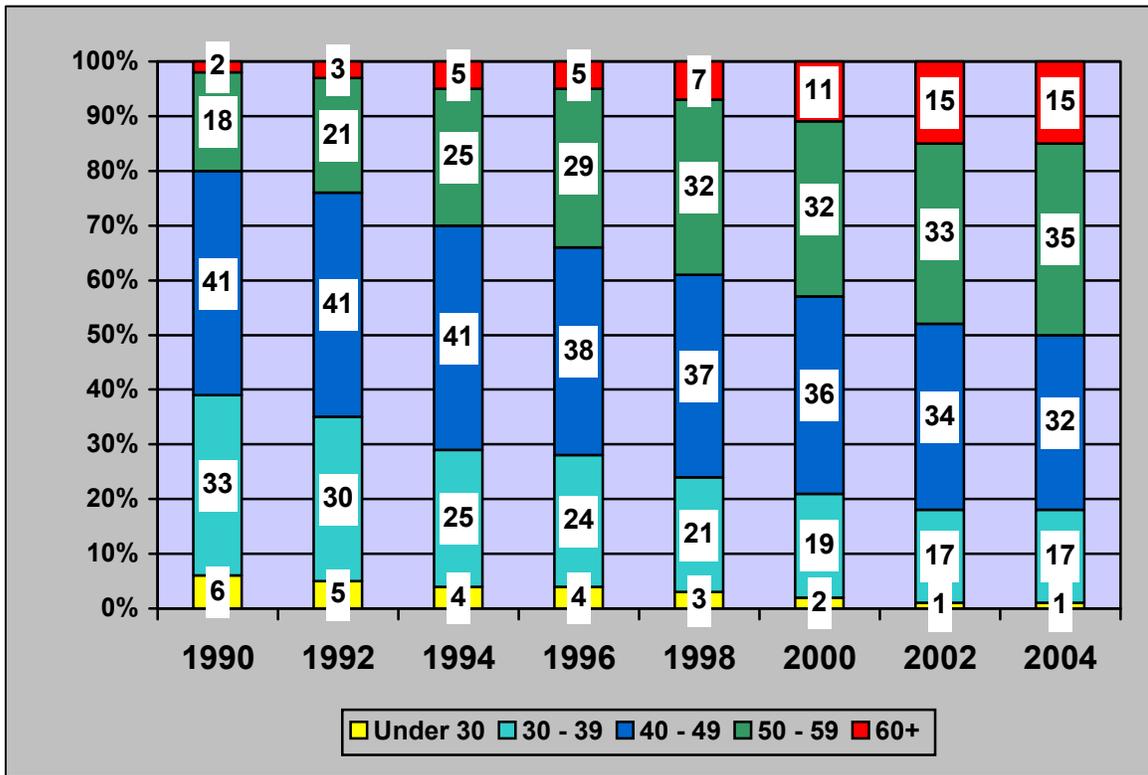


Figure 3.3: Author age demographics (Source: CREST)

As evident from Figure 5, in all the selected scientific fields more articles are published by the age group over 50 years. A similar trend is depicted in the article publication of the top 20 authors, as shown in Figure 6 below.

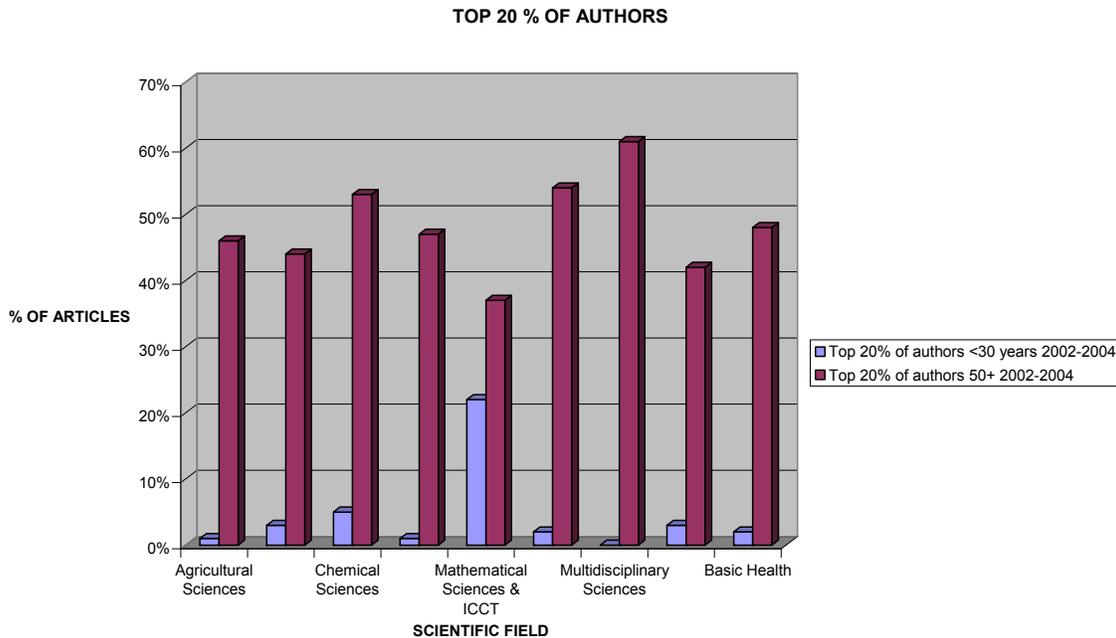


Figure 3.4: Age profile of the top 20 authors of scientific publications (2002–2004)

Economic growth and wealth creation are based on innovation. With the challenges mentioned above it becomes difficult for economic growth to be stimulated through innovation. Various legislative and institutional reforms have been introduced to create an enabling environment for innovation to take place. The political changes that took place in the country in 1994 had an impact on the S&T policy framework. These political changes led to the introduction of new S&T policies, aligned to the current macroeconomic framework. All these policies are, however, operating within the contextual realities of the legacy of apartheid, namely the uneven and unequal development along racial lines. Underlying all policy initiatives is the dual commitment of addressing the challenge of competitive integration into the global knowledge economy as well as contributing to equitable national economic and social development (Kruss, 2006:3). GEAR has been applauded for its success in stabilising the economy, particularly the country's currency. An inhibiting factor identified that has affected the potential of GEAR to achieve its full potential is skills shortage. Subsequently, with the introduction of ASGISA, skills development has been identified as one of the pillars critical for the success of ASGISA. The current shortage of skills will have a negative impact on achieving the objectives of ASGISA. The S&T system, which has an important

role to play in making ASGISA a success, also faces the challenge of skills shortage (Kahn and Blankley, 2004:272).

The policy framework for S&T was influenced by the RDP and GEAR. The relevance of the RDP principles in the S&T arena was articulated in the Green Paper on RDP . The Green Paper focused on the role that S&T should play in the post-isolationist society and the general integration of the S&T system in society to improve the quality of life of South Africans. It also focused on the challenges of fragmentation of the South African S&T system (Green Paper on S&T, 1995). GEAR was used as a point of reference in drafting the White Paper on S&T. The White Paper on S&T clearly states that a concerted effort must be made through government structures to integrate the NSI into dominant policies of government such as GEAR. The White Paper was aligned with national imperatives, particularly aspects related to the improvement of quality of life, such as job creation and poverty alleviation. It is not surprising, therefore, that the institutions within the NSI are supporting the objectives of GEAR, such as economic competitiveness. To achieve GEAR objectives, the South African S&T system has introduced various policy measures and funding instruments. Of relevance to this chapter is the IF, which was introduced in the White Paper in 1996 but was only implemented in 1997/1998(Innovation Fund Annual Report, 2002/2003).

The focal point of the White Paper is on the NSI, which is a combination of all stakeholders within the S&T system. These stakeholders include institutions of higher learning, science councils, research facilities, non-governmental organisations and other statutory bodies (Kahn, 2006:129). The introduction of the NSI in the White Paper was an attempt to deal with fragmentation within the S&T system. One of the challenges identified in the NSI is human resource capacity, which affects R&D outputs and consequently innovation. Poor innovation at HEI level is a combination of many factors, which include a low ratio of full-time researchers and the increase in number of students at HEI versus the increase in the number of staff.

It can be argued that the current S&T policy framework is geared towards the expansion of innovation as envisaged in the White Paper on S&T. The White Paper acknowledges the necessity of innovation in economic growth. Furthermore, it focuses on measurable outputs of the S&T system, namely the creation of new knowledge and the generation of

new technologies. It also raises a number of challenges identified in the NSI. These challenges include fragmentation in the S&T system, human resource development, frozen demographics, innovation chasm and low expenditure on R&D activities. The White Paper seeks to produce the abovementioned outputs and promotes changes in the way society and the economy operates through legislative and institutional reform. Implementation of these reforms has not been without challenges. The focal point of this research report, namely the NIC, is an attempt to address some of these challenges.

To achieve the objectives of the White Paper and address the challenges outlined, the DST supports and promotes the attainment of national priorities through the following:

- Create an enabling environment for the different institutions, organisations and policies to achieve the different functions of an NSI.
- Ensure and encourage constant and constructive interaction among the stakeholders in the NSI.
- Develop a common vision, goals and objectives within the institutions that constitute the NSI (Cenis, 2001:6).

3.5.2 THE RESEARCH AND DEVELOPMENT STRATEGY

The National R&D Strategy (2002) has three pillars, namely innovation, SET human resource development and transformation as well as the creation of an effective governance of S&T system. The innovation pillar is responsible for the creation of an enabling environment for innovation to take place. This includes funding of innovation in key technology missions such as biotechnology and information and communication technologies. The R&D strategy has identified one of the challenges facing the NSI in South Africa as the gap between innovation and the market. This is reflected through the gap that exists between the knowledge generators and the market, which is known as the 'innovation chasm'. Attempts to close the innovation chasm have focused on connecting the human capital function closely with the market. The approach used within the NSI to link the human capital function to the market drives the academic system towards short-term, incremental problem solving and consulting, which tends to reduce the importance of academic research (CHET Report, 2003:3).

Additional strain comes from the intensity of pressures on academic work. This includes more demands on academic institutions to diversify their student body as well as administrative pressures to increase accountability. Consequently, the increased student demands for attention makes undergraduate teaching much more demanding. On the other hand, there are demands to increase graduate enrolments and output, increase research output and increase research funding activities. Evidently most institutions are inclined towards more undergraduate work and are generally biased towards differentiation and specialisation. This predisposition leads to the academic resistance towards splitting either the task of financing or the task of research. This status quo has caused a strain in most academic institutions, which has led to the emergence of the phenomenon of casual teaching and research labour. This phenomenon is seen as a temporary measure to relieve pressure, which has more negative than positive consequences. Consequently, the prevailing situation in academic institutions leads to the downgrading of academic research, which causes teaching overload and the privatisation of knowledge (DST R&D Strategy, 2002:35). It can be argued that the challenges of transformation, accountability and funding have a negative impact on teaching and research in the HEI. This affects research outputs such as publications, which puts South Africa lower on research outputs when compared to its international partners. The low research outputs, coupled with the challenge of the frozen demographics in the South African S&T system, pose the greatest challenge to the NSI.

3.6 THE INNOVATION FUND

Since science, technology and innovation are key drivers for economic growth, it is evident that S&T should be a major player in implementing ASGISA. According to the Innovation Fund Business Plan (2005/2006), economic growth occurs where there are interrelations between physical capital, human capital (education and training), innovation (introduction of new products and production methods/processes action) and competitive markets. Innovation depends on continued technical progress and knowledge generation. Knowledge is generated from the higher education sector, science councils and national laboratories. An increase in knowledge generation results in higher R&D intensity. This leads to new products that are traded in competitive markets (DST Corporate Strategy, 2002-2005). This argument implies that the more human capital the economy has, the greater the likelihood that more innovations will take place and that new products will eventually be sold in the market. This leads to

economic growth and sustainability. A lack of educated human capital (as is the case in South Africa) can affect new knowledge generation and economic growth and sustainability.

The challenges outlined in the White Paper and R&D strategy and the proposed solutions fit in neatly with ASGISA objectives of achieving economic growth, as mentioned earlier. The DST commitment to achieve economic growth and support innovation is done through the IF, which provides funding for innovation. This encourages participation of the private and the public sector. The majority of innovations that have economic value are technological/ scientific in nature (DST Corporate Strategy: 2002-2005). Increasing the flow of innovation is viewed as a continuous increase in the broad body of knowledge available to innovators, and investments in innovation create economic growth.

As already mentioned, to rectify the lack of innovation the White Paper introduced a policy instrument called the Innovation Fund. This fund encourages collaborative research and technology development programmes. It also encourages a multi-disciplinary approach to problem solving, as well as application-based research programmes. This fund was established by the then Department of Arts, Culture, Science and Technology (DACST) in support of the NSI in 1997/1998.

The aim of the IF is to enhance R&D in South Africa. Its main objectives are as follows:

- To promote and enhance the effectiveness of technological innovation by the research community.
- To promote the key issues of competitiveness, quality of life, environmental sustainability and harnessing of information technology.
- To promote multi-disciplinary and cross-sectoral collaborative research and development programmes that have innovation as a desired outcome.

Projects funded through the IF create commercial products that contribute to job creation, sustainable development and improved quality of life. The minimum funding for a project to qualify for the IF is between R1 million and R5 million for two- to three-year collaborative projects aimed at technological innovation (Innovation Fund Management Contract, 2002:2).

The focal areas supported in the past have been:

- Crime prevention
- The promotion of the information society
- Biotechnology (genetics-based)
- Value addition in respect of exploitation of our natural fauna and flora and advanced materials and manufacturing (www.dacts.gov.za).

The IF ran a small pilot round in 1997/1998 before the first full round took place in 1998/1999 for a three-year cycle, which ended in 2001. After the completion of the cycle in 2001 an evaluation was conducted. The findings showed that some of the IF objectives had been achieved at that time. In particular the IF had managed to foster greater co-operation and collaboration within the S&T community, which was not the case before. The funding allocation pattern has also changed, with money allocated to the science councils now open to other organisations such as academic institutions and industry. The IF also introduced a competitive bidding process. Longer-term objectives such as improving the quality of life were difficult to assess. However, project leaders have been able to quote the number of jobs created as a result of the IF projects. For rounds 1 to 3 the evaluation process revealed that approximately 55 new jobs had been created and 6 new firms were established. Significant intellectual capital had been created with at least 10 new patents registered and 12 new software products created from the first two rounds. One of the key weaknesses that affected the performance of the IF initially (during the period of evaluation) was poor management of the fund, caused by lack of resources and capacity within DACST. This led to a long process of applications and the awarding of funds as well as lack of feedback to applicants. As a result, the applicants viewed the process as being unfair and decisions being made arbitrarily. The evaluation was done internally within DACST with very little external input and there was no consistency in the quality of project monitors. Subsequently, the recommendations of the evaluation were implemented. This led to changes in the management of the IF. It moved from DACST to the National Research Foundation (NRF), which acts as the current implementing agency for the DST. Some improvements in management and disbursement of funds were recorded. Evaluations of other rounds of the IF revealed that the IF is doing well. Another aspect that the IF is making progress on is the issue of intellectual property, where partnerships with private sector legal

experts have been entered into to build internal capacity in this area (Innovation Fund Annual Report, 2004/2005). Due to an increased demand for resources, a lack of resources is another challenge facing the IF. Initially the IF funded four focus areas, namely biotechnology, new materials and manufacturing, information and communication technology, and fauna and flora (Innovation Fund Business Plan, 2005-2006).

Another key weakness was the strategic positioning of the IF within the NSI, particularly the articulation of its aims and objectives to researchers and other stakeholders. There was no broader socioeconomic strategy informing the positioning of the IF and the investment themes and categories. There was also no consultation with the broader stakeholder communities regarding what positioning the IF should have and what specific focus areas should be invested in. The report made a number of recommendations. Central among them was the issue of the strategic positioning of the IF. The team recommended that this positioning is clearly defined within the broader economic and social development framework with input from stakeholder communities. A second recommendation was with regard to management and corporate governance of the IF. A governance structure outside of DACST was recommended and control and transparency measures were to be introduced to avoid the misuse of funds. After the implementation of the recommendations, certain improvements in the IF were recorded (Evaluation of the Innovation Fund Programm, 2002). In 2004, major accomplishments such as the establishment of the Commercialisation Office (to facilitate the commercialisation of the IF projects and establishment of the start-up companies) and the Patent Management Office (to manage intellectual property such as research publications, scientific manuals, course work, software, trademarks and patents) were recorded (Innovation Fund Business Plan, 2005-2006). Despite these successes, more innovations from the HEIs are needed. As a result of the need to encourage innovations from the HEIs the NIC was introduced in 2004. The NIC also seeks market opportunities for innovative products generated from HEIs (Innovation Fund Business Plan, 2005/2006).

Despite these efforts to encourage innovation, it is acknowledged that the IF's impact on the economy is difficult to predict because it is dependent on the unpredictability of the direction in which the scientific knowledgebase will develop. From the recent evaluations

a central issue is that innovators face a great deal of obstacles before their products can successfully reach the market place. This requires a lot of perseverance and risk taking in exchange for expected economic gains. According to the IF evaluation reports, innovators can emerge from any social class. Increasing accessibility of funding instruments to the broader society increases the probability of successful innovations and thereby the spread of wealth across the nation (Innovation Fund Business Plan, 2005/2006). Innovation incentives should adequately cater for financial risks. A major concern to innovators is that the spill-overs can generate benefits to those who are not initial investors, which may lead to market failure and reluctance to invest. The private sector may also invest in pre-competitive technologies. Availability of intellectual property legislation may ease this tension (Innovation Fund Business Plan, 2005/2006).

3.7 THE NATIONAL INNOVATION COMPETITION

Together with the task of investing in knowledge generation, diffusion and use, government also has a responsibility of creating a conducive institutional environment that supports entrepreneurship and innovation. This is a prerequisite for technological advancement, which is a key driver for economic growth. Technological advancement is also important for achieving long-term objectives such as improvement of the quality of life. Technological advancement also plays a critical role in closing the innovation chasm, skills development and bridging the gap between the first and the second economy. Among the challenges facing South Africa is the challenge of unemployment. Entrepreneurship has widely been considered as a solution to economic and unemployment problems. There has been reluctance from the academics to generate their own employment or to be self-employed, as many bright people do not have the spirit of entrepreneurship (Kafta, 2002). There is evidence that many successful innovations such as Yahoo, Google and the internet also started at academic and research institutions (Rahardo and Achmad, 2002). In the South African context, especially within the S&T system, various incentives have been introduced to encourage academic entrepreneurship to foster the link with industry. The NIC is one of the policy instruments to assist in improving innovation in South Africa.

The NIC is the first of its kind in South Africa. The competition is an initiative of the IF to encourage innovation at the level of HEIs. It was launched in mid 2004 to build capacity

at HEIs and promote the commercialisation of innovative ideas of student entrepreneurs as well as capacity building (Innovation Fund Annual Report, 2004/2005:10). This is done in two ways. Firstly through sourcing and marketing higher education business plans to potential funders, and secondly through identifying and marketing the most technologically innovative HEIs. This is meant to stimulate innovation and entrepreneurship at the participating institutions. The competition is open to all registered students (i.e. full-time, part-time and distance learning students) at all South African HEIs and science councils (Innovation Fund Annual Report, 2004/2005:22). Students are required to develop business plans with the following requirements:

- It must be a technological innovation.
- It must be a tangible product or service.
- It must be a potentially financially viable business.

The first phase of the competition consists of each participating institution running its own internal, customised business plan competition to select its top three business plans for the national competition. This is known as the Institutional Innovation Competition (Innovation Fund Annual Report, 2003:23). The IF sponsors the participating institutions with R150 000. R50 000 is used to run, manage and facilitate the competition. The remaining R100 000 is used as prize money for the top three business plans. The top three business plans from each participating institution are automatically entered into the national competition. The IF then shortlists the 12 best business plans and present them to a national panel of judges, possible investors and sponsors at a business trade fair, where the top three business plans are selected. At national level the prizes are as follows :(National Research Foundation: Newsletter, No 2, June 2004:10)

- The first prize is R300 000 (50% student/team and 50% to the department(s)).
- The second prize is R200 000 (the same allocation as above).
- The third prize is R150 000 (the same allocation as above).

The second phase involves that institutions themselves compete for the most technologically innovative HEI and the most progressive technologically innovative HEI in the country. Stellenbosch University won the prize for the most technologically innovative HEI and the North-West University for the most progressive technologically innovative HEI. The overall winner of the best business plan was Clinton Bemont's team

of the UKZN for Smart Bolt, which is a technology used in the mining and construction industry. A total amount of R2 150 000 was awarded by the IF to students and institutions. Part of the money will be used to support previously disadvantaged students (Innovation Fund Annual Report, 2004/2005:10).

According to the Innovation Fund Annual Report of 2004, in addition to the prize money, the IF will also grant the winning student/student team to represent South Africa in a similar international competition. The IF will award the most technologically innovative institution with a prize of R1 million.

The 2004 NIC had a total of 20 participating HEIs and 60 business plans. Potential investors have been sourced to implement the business plans. The 60 business plans were showcased at an exhibition in April 2005. This was done mainly to expose the business plans to the business community (Innovation Fund Business Plan, 2005/2006:26). Lessons learnt from the previous competition include the NIC exploring the possibility of creating a single platform for innovation countrywide. This will emphasise private-public partnerships that will allow the IF to use the databases of rich business mentors in support of the development of the business plans of young burgeoning entrepreneurs.

For the 2005 NIC, the first prize of R300 000 went to Wernich de Villiers of Stellenbosch University. The winning innovative idea is a Line Trap Tester, which will have a substantial beneficial impact on the high voltage power line carrier maintenance industry worldwide. This technology will be used by power utility companies. It is protected by the Patent Co-operation Treaty (PCT) and is currently being introduced to the world market. The second prize of R200 000 went to Gerrit Smith and Johannes Strauss from Stellenbosch University, for the Solar Submersible Water Pump. Their objective was to develop a range of solar water pumps to cater for all possible customer needs, and simultaneously establish the strongest, most effective marketing, distribution and service network in South Africa. This technology is intended to become the fastest growing solar pump manufacturer in the world and the market leader in South Africa within five years of production. The third prize of R150 000 went to a team from UCT for their Next Generation Personal Tracking Device. Using proven technology in a 3 x 6 x 2 cm enclosure and with the support of an online server, the product allows a user to track

anything via the internet with his/her own cell phone. The device runs on a cell phone battery for up to a week. It is rechargeable via a car cigarette lighter (www.naci.org.za).

In this chapter a picture of the South African S&T system was presented by outlining the history of the South African S&T system, the policy environment, the governance structure as well as challenges and policy instruments that are currently implemented to address some of the challenges. This chapter has demonstrated that some of the challenges that the system is currently facing have emanated from the past. It has also demonstrated that due to isolation of the past, the South African S&T system has grown stronger in the fields of agricultural science, mining and defence technologies as a result of the need to become self-sufficient. This chapter has also demonstrated that South Africa has a sophisticated S&T system, with state-of-the-art institutions and infrastructure. However, the expenditure on R&D remains relatively low when compared to OECD countries, although there is remarkable improvement from the 1993 figures. These low figures on R&D expenditure are similar for most developing countries. As a result of low investment in R&D, South Africa ranks low in technology innovations. This can be attributed to a number of reasons, such as the legacy of apartheid, overstretched human resources, as well as the current funding model for higher education.

South Africa acknowledges the significance of S&T innovations as an important contributor to economic development. This is reflected in the government policies that are aimed at providing incentives to encourage innovations, particularly at academic institutions. In order to address some of the challenges related to poor innovations, the government has embarked on initiatives to encourage innovations at all levels. The IF is one of the instruments used to encourage innovations at all levels. Some successes have been recorded in terms of the number of projects funded through the IF since its inception. However, the benefits of the IF have not made a major impact within the academic institutions. The number of projects funded by the IF for the academic institutions remains very low. Government acknowledges that the academic institutions should be at the centre of innovations. As a result, the NIC was introduced in 2004 specifically to target academic institutions by providing incentives to the institutions and their students for innovations.

3.8 TECHNOLOGY AND HUMAN RESOURCES FOR INDUSTRY PROGRAMME (THRIP)

Amongst the innovation incentive schemes supported by the government of the Republic of South Africa, the technology and human resources for industry programme (THRIP) is considered to be one of the success stories, as reflected in the THRIP Impact Report ;2008) . Some of the measures of success for THRIP are the number skills development at HEI level as well as practical solutions to industry challenges. This programme was formed in 1991..."to respond to challenges of South Africa's emerging democracy, specifically high level skills development in science, engineering and technology to improve industry's competitive edge" (THRIP Impact Report, 2008:2).

Its main objective is to promote innovations and the improvement of competitiveness of the South African industry by supporting research and technology development activities and enhancing the quality and quantity of skilled people. It focuses on developing S&T skills which will lead to job creation and social upliftment. Primarily, it transforms students into specialists in the field of S&T innovations to contribute to economic upliftment, with a particular focus on the SMME sector. This programme is run jointly by the NRF and the Department of Trade and Industry. It is designed is to address the skills shortage for industry as well as the need to improve the competitive edge of South Africa's industry through development and diffusion of advanced technologies. This programme has traditionally focused on the manufacturing sector, but attempts are now being made to diversify and focus on the services sector. (THRIP Strategic Plan, 2003-2007)

When THRIP was established in 1991, the DTI approved a budget of R1.5 million. This was later increased to R6.7 million in October 1993, when the first projects were approved. The first grant was only released in 1994. DTI contributed R1 million for every R2 million contribution from industry. During 1995/1996 DTI made a contribution of R14.84 million. In 1996/1997 DTI contributed R26.7 million. (Evaluation of THRIP Final Report, 1997:7-12). This figure has grown to R130 544 827 for the 2007/2008 financial year. The support for students has also grown tremendously; In 2007/2008 THRIP supported 2054 students. Out of the total number of students supported, 1111 were black students and 790 were females. Almost half of the students working on

THRIP projects were registered for a Masters degree (THRIP annual report; 2007/2008:7).

In a review of this programme, which was done in 2001, some strengths were identified. These include the improvement in the participation of women in this programme, participation of Universities of technology as well as an increase in THRIP funding. The weaknesses include lack of data to assess projects that have been supported, low participation of HDI's, lack of marketing strategy for the programme. In moving forward THRIP is addressing those weaknesses and building on the existing strengths (THRIP Strategic Plan, 2003-2007).

The THRIP Impact report of 2008, which covers the 2006-2008 reporting cycle, 54 project leaders and 94 industry partners responded. Of the 94 partners surveyed, 42 were SMMEs. These SMMEs have indicated that THRIP has helped to expand their networks and access scientific expertise in academia. They have also stated that one of the benefits of THRIP is access to available equipment at HEIs and SETIs. This is viewed as bridging the innovation chasm, which is sighted as one of the challenges in the South African NSI. This helps to provide the links needed to transform scientific R&D into commercially viable products and solutions. (THRIP Impact Report; 2008:7)

Chapter 4

METHODOLOGY

To complement the literature review on academic entrepreneurship, personal interviews were held with selected individuals within the academic entrepreneurship fraternity. This method consisted of in-depth interviews with a group of people who are involved from different perspectives in academic entrepreneurship. The interviews also provide insider perspectives of both policy makers of and participants in the NIC.

The interviews were conducted in August and September 2006. The interviewees were drawn from the top management of the DST, the NRF as well as academic institutions that have previously participated in the NIC. It should be noted that because the NIC is a new entity, the availability of participants has been very limited. The list of individuals interviewed includes the following:

- ❖ Dr Philemon Mjwara: Director-General of the DST
- ❖ Dr Adi Paterson: then Deputy Director-General responsible for Science Expert Services, DST
- ❖ Mr Dhesigen Naidoo: then Deputy Director-General responsible for International Co-operation and Resources, DST
- ❖ Mr Steven Ratsatsi: Senior Manager responsible for the IF, DST
- ❖ Ms Ela Romanowska: Seed Fund Manager, NRF
- ❖ Dr Rudi van der Walt: Director of Innovation, the North-West University (also winner of 2004 NIC).
- ❖ Prof Steyn: Stellenbosch University
- ❖ Prof Thomas auf der Heyde: Director of Research and Innovation at the University of Johannesburg
- ❖ Mr JP Klopper: Manager: NIC, NRF
- ❖ Jan Mentz: then Head: Contracting and Intellectual property, University of Pretoria

Attempts to interview another five key people at various institutions were not successful. As this research report is a qualitative study, no structured questionnaire was designed.

However, a list of semi-structured questions was developed in order to guide and direct the interviewing process. These questions include the following:

- What would you regard as the most important effects of the Innovation Fund on the National System of Innovation?
- Have these effects been uniform across the system or different for different institutions?
- What do you view as the main purpose of the Innovation Fund?
- What should its main goals be?
- Have these goals been realised? If so, how?
- How do you rate participation in the Innovation Fund? Which institutions participate better and for what reasons?
- What constitutes a non-winning business plan?
- What support systems and monitoring mechanisms does the NIC provide to the winning institutions?
- What mechanisms does the NIC provide to encourage further participation in the Innovation Fund?

In addition to the literature review conducted, the research also incorporated a third component, namely a documentary analysis. This component focused on a review of the business plans from the participants of the previous NIC. The main purpose of this review has been to identify key aspects that determine whether a business plan wins or loses. The intention is to provide a template as part of the conclusion that will guide future participants on how to win the NIC.

The interviews with the senior management of the DST were held at the DST offices. Other interviews were conducted telephonically and via email. The average length of the interviews ranged between 20 and 30 minutes. The one-on-one and telephonic interviews were transcribed. Copies of the transcripts have not been attached to protect the identity of the interviewees. On the basis of the depth of the information gathered through the interviews, it can be argued that the quality of the interviews was good. The people interviewed were open and appeared very knowledgeable about the subject. This can be attributed to the level of seniority of the people, particularly those from the DST, as well as the level of technical expertise of the people from the academic institutions and the NRF.

Chapter 5

KEY RESULTS AND ANALYSIS

5.1 INTRODUCTION

The purpose of this chapter is to present an analysis of the results from the personal interviews. As already mentioned in Chapter 4, a set of questions were developed to guide the interviewing process. The questions were used to guide and structure the presentation of the analysis. Responses have been analysed per topic or question. The main themes covered are as follows:

- ❖ The most important effects of the IF on the NSI
- ❖ Consistency of these effects across the system
- ❖ Differences in effects across different institutions
- ❖ Main purpose of the NIC
- ❖ Main goals of the NIC
- ❖ Rate of success in achieving the goals of NIC
- ❖ Participation of HEIs in the IF
- ❖ Which institutions participate better and for what reasons?
- ❖ Important components of a winning business plan
- ❖ Components of a non-winning business plan
- ❖ Support systems and monitoring mechanisms provided by the NIC to the winning institutions

5.2 KEY FINDINGS

In analysing the responses from the interviews, one of the prominent observations clearly articulated is that South Africa is moving towards academic entrepreneurship, which is consistent with international trends. As reflected from the interviews and literature review in the previous chapters, one of the mechanisms through which academic entrepreneurship is implemented is the NIC, which is one of the IF's funding instruments. In general, as is evident from the interviews, the IF has made breakthroughs in encouraging innovations and partnerships among private sector companies, science councils and other research institutes. Within the academic institutions, the IF has not had as much impact due to the conditions under which some

HEIs operate. These conditions include the choice that some HEIs have to make between increasing numbers of student enrolments as opposed to conducting applied research. Increasing student enrolments is usually regarded as vital for continued existence of the HEIs, whereas applied research is seen as less of a priority. A small number of academic institutions that have benefited from the IF represent the previously white universities, as they have committed resources targeted for sourcing research funds. The HDIs, on the other hand, do not have similar resources or seemingly a similar commitment to entrepreneurial projects. As a result they have not been able to access and benefit from the IF. The creation of the NIC is an attempt to change the current situation and broaden participation of HEIs in linking innovations and economic development. The NIC has a special focus on postgraduate students. The non-financial support such as assistance with patent issues is viewed as an important initiative. As a result, the NRF has now injected more funds to support patent activities, as reflected in Table 2 in Chapter 1 (progress made in supporting patent activities)

5.3 DETAILED FINDINGS

5.3.1 The most important effects of the Innovation Fund on the National System of Innovation

On the role of the IF in the NSI, the dominant view emerging from the interviews is the provision of financial support to individuals and entities for generating innovative ideas and encouraging those ideas to reach the level of marketable products. In technology lifecycle timeframes of five to ten years, the IF is still fairly young, and already a few success stories are emerging, where technologies are making a real impact in people's lives. Examples are Eyeborn, a ceramic-based artificial eye that provides superior features at half the price of internationally produced products, and Geratech (a technology applied to beneficiate zirconium such that South Africa can export the processed material at many times the price of the raw ore it mines. Of importance and as part of the package offered through the IF is non-financial support such as the drafting of the business plans, legal support related to patenting as well as marketing of the concept to potential investors. Throughout the interviews interviewees echoed a gap identified in the HEIs, which is viewed as one of the causes of slow progress in innovations in South Africa.

“The IF provides funding to encourage innovation. It also provides security for academics to redirect some of their academic activities towards applied research. This encourages those who have only been focusing on publishing because of the financial rewards to have incentives to get involved in applied research.”

This gap identified through the interviews is caused by one of the harsh realities of the South African higher education system, namely the choice that HEIs have to make between conducting basic research and teaching versus conducting applied research.

“Opportunities for research available through the NRF and NIC are not fully utilised by the HDIs because these institutions are focusing on their survival rather than other activities such as conducting research.”

As a result of this harsh reality, the NIC was established in 2004 to focus specifically on promoting innovations at HEIs. The most innovative students and institutions win a national prize, which is intended for use in advancing the winning concept. Although the NIC is fairly new, it is making a difference in changing the way universities view their role in the innovation cycle. It has encouraged researchers to work in partnerships with each other with the possibility of economic benefits. It has also encouraged specific academics to consider working with each other to achieve breakthroughs in innovation. Most importantly,

“. . . it is also viewed as a tool used in promoting awareness amongst researchers and innovators about issues related to intellectual property and patents.” It has also helped them in making them aware of intellectual property and patenting issues”.

Another view that emerged from the interviews is that the NIC has made a huge impact in creating awareness of commercialisation of HEIs.

“Through prestige, the business plan competition encourages research in the context of applied research because of the benefits involved in applied research. It also encourages creation of entrepreneurship.” (Interviewee from the academic institutions)

However, one contrasting view is that the majority of South African HEIs are still stuck in conducting basic research, teaching and transformation.

“Academic institutions have not given themselves time and space to have research plans. They are more focused on transformation and teaching issues as well as battling for survival in the context of the new funding formula.”

However, as a result of the international influence of academic entrepreneurship, some HEIs in South Africa are beginning to encourage academic staff and students to conduct applied research.

“The NIC has shifted focus from big projects to student ideas. In that way it builds capacity of future innovators and researchers by giving them an incentive to innovate. The incentive is meant to ensure that the idea is taken to the next level of marketing and patenting. It also encourages collaboration between staff and students. It also links technology innovations to business planning.”

From these different viewpoints, it can be concluded that the IF has had a major impact on the NSI through the provision of financial support to individuals and entities for their innovations. It can further be concluded that in addition to the need for financial support, the non-financial support in the form of encouraging the innovative ideas to reach the level of marketable products is well received and appreciated. Other non-financial support such as assistance with the drafting of business plan is viewed as adding value to the process of innovations. A gap that has been identified is the pressure on academic staff to focus on basic research instead of applied research.

5.3.2 Consistency of effects of the Innovation Fund across the system

A dominant view expressed during the interviews is that the effects of the IF have not been uniform across the system.

“The previously white institutions usually have support and resources to look for the different funding opportunities that are available. In particular they have dedicated individuals who also give support in terms of monitoring the closing dates, adherence to the requirements, etc.”

The IF is more favourable to science councils as well as the previously white academic institutions, as shown by the number of grants awarded to them. These institutions are geared to benefit from IF funding because they have the technical expertise to develop feasible business plans to access funding. Another view is that those academic institutions who have not benefited from the IF, have not given themselves time and space to develop viable business plans. These institutions spend most of their time focusing on transformation issues and teaching as well as battling for survival under the current funding formula, which is attached to the intake of students in the academic institutions.

“The HDIs, on the other hand, usually have people doing everything and therefore miss out on some funding opportunities that they would have benefited from. These people usually do not have knowledge of how to look and where to look for opportunities.”

Some HEIs have been discouraged from applying for IF funds because of uncertainty that they will ultimately get the funds. A different view expressed during the interviews is that the IF concentrates on high levels of funding. As a result, some institutions, especially the HDIs, believe that they will not be able to secure such huge amounts of funding as they view these huge sums as beyond their scope.

“Unlike the private sector and the science councils, this collaboration has not happened in the academic institutions.”

Contrary to the private sector and science councils where there are active collaborations, this is not the case at HEI level.

Another view expressed throughout the interviews is that some institutions are not well set up to support aspects of sourcing of funding. In this regard, there is a need to build

capacity. Other institutions are not willing to form partnerships with HDIs and have created mechanisms to avoid working with each other. There is a general lack of good commercialisable research, because HEIs tend to focus more on general research. This is linked to a lack of proper industrial knowledge. However, as already mentioned, leading institutions in South Africa are moving towards conducting more applied research.

HEIs have benefited from IF funding in general, and most have participated at least once in the NIC. Over the past two years, since the NIC came into existence, many HEIs have been involved in fairly intense re-organisation due to mergers that have taken place. This was a significant factor preventing some institutions from participating. A further factor is the capacity within the HEIs to promote and foster innovation. Therefore, some institutions participated in the first student business plan competition, gave the second one a miss, and are now eager to participate again since in two years they have gained a new crop of students with novel ideas that could be entered into the competition.

From the interviews, interviewees have expressed a view that the impact of the IF has not been uniform across the NSI. There is evidence that science councils and the previously white academic institutions have benefited more than the HDIs. This can be attributed to a lack of dedicated resources to participate in these initiatives on the part of the HDIs as well as a need to strike a balance between basic research and applied research.

5.3.3 Main goals and achievements of the National Innovation Competition

Interviewees stated that they view the NIC as an instrument of the IF which is dedicated to the promotion of academic entrepreneurship in HEIs in South Africa. Its main objective is to focus on student ideas and encourage the creation of a culture of entrepreneurship in HEIs. This has been done through the promotion of research in the context of applied research because of the benefits involved in applied research. In this way it builds capacity of future innovators and researchers by giving them an incentive to innovate. The incentive is meant to ensure that the idea is taken to the next level of marketing and patenting. It also encourages collaboration between staff and students. The main focus of the NIC is the linkages that it encourages between technology innovations and business planning by providing funding to encourage innovation.

“The NIC can also be seen as a marketing tool to learn more about funding options and incentives offered through the IF. It also shows other aspiring innovators that other people can do it. It is used to inspire other people to be part of the club. It also incentivises the research community through recognition in the form of prizes.”

“Despite the successes of the NIC, the NRF and DoE still need to work closely together to deal with the fundamentals that are not right in South Africa such as the poor matric pass rate which limits the number of students to enrol in the fields of S&T at academic institutions. This is where we should focus on, the youth, who will be our prospective innovators.”

The NIC also provides security for academics to redirect some of their academic activities towards applied research. This encourages those who have only been focusing on publishing because of the financial rewards to get involved in applied research.

In general the interviewees regard the main aims of the NIC as targeting HEIs to participate in innovations through the provision of incentives to both students and the institutions. The NIC is seen as a good initiative, which nurtures new innovators who are perceived to have fresh ideas. The NIC is also seen as a shift from the traditional way of targeting innovators who are experienced. This shift from the tradition of targeting experienced innovators is regarded as a way of opening opportunities for emerging innovators. It also provides recognition for innovative ideas with potential.

The goal of the NIC should be to encourage applied research at HEIs through the different competitions, namely the student competition and the institutional competitions. It should also emphasise the importance of applied research in problem solving and incentivise students through the winning of the prize. Encouraging applied research is related to the fact that despite the incentives, the universities have to change their research culture. Interviewees agree that most participants in the student competition are postgraduate students because they have well-researched concepts. It is believed that, although there are ideas at the undergraduate level, they have not been well researched and some are not practical. The main thrust of the NIC is to shift the focus

from the publication of papers to applied research and to generate projects that are innovative across the board. *“In that way it builds capacity of future innovators and researchers by giving them an incentive to innovate”*. It also encourages partnerships with other institutions and the private sector. One of the goals is to achieve creating awareness of the concept as well as the IF’s role in it. By focusing on students, that awareness is being raised among the next generation of techno-preneurs that is entrepreneurs who are eager to create new enterprise from new technologies. The NIC is structured to maximise limited resources to allow some form of training to students in the writing of business plans, which is a key skill in establishing a bankable business.

“For the period of its existence, the NIC has achieved its goals of encouraging students and academic institutions to be innovative.” (Interviewee from the academic institutions)

However, it is still early to measure success. The NIC has run the student business plan competition twice, and the HEI competition once. This is a critical initiative, but its impact will only truly be measured in the five- to ten-year timeframe. The impact must also be measured in the context of the capacity within HEIs to promote entrepreneurship and the development of new technologies from research activities. A proxy for this is the level of technology transfer activity in these institutions. It is important to acknowledge that 10 years ago, no HEIs had TTOs, and today a few have fairly well-established ones, and a few are starting to put together such capacity. It is almost impossible to measure their outputs as yet, since they are only being established. A further indicator is the level of awareness of entrepreneurship, and the means by which such awareness is being raised. Some HEIs are progressive and offer entrepreneurship as part of programme curricula. Others still have a long way to go. It is envisaged that the NIC will contribute to the development of awareness of entrepreneurship, though the focus is on technological innovation, or the creation of enterprise based on new technologies that have been developed.

“It provides funding over a period of time. It also provides an opportunity for the participants and the winners to be part of a network in discipline. It also provides an opportunity for collaborations.”

Despite the difficulty of measuring success within a short space of time, an area worth mentioning is the provision of financial incentives to individuals and institutions. Some success has also been recorded in encouraging individuals and institutions to work together. The NIC has also been used as a marketing tool to learn more about funding options and incentives offered through the IF. The NIC also provides patent support to both institutions and individuals. The NIC demonstrates to aspiring innovators that other people can do it and has been used as an inspiration for those who want to participate. The recognition in the form of prizes is an incentive to the research community.

However, there is also the view expressed that the NIC is generally still unknown.

“NIC is fairly new and relatively unknown within the different faculties of academic institutions. An aggressive communication and marketing strategy can help to publicise it.”

A communication strategy needs to be developed to assist in marketing the IF. This will include communication and publicity to realise research outputs. Another area that impacts negatively on the success of the NIC is the inability of some institutions and individuals to come up with innovative ideas.

The interviewees have expressed a general view that the goal of the NIC is to encourage active participation of HEIs in innovations from the stage of conception until the concept reaches the level of a marketable product. Although the interviewees have acknowledged that the NIC is a fairly new initiative, it is regarded as having achieved its goals. Its impact is measured by the number of HEIs that have participated in the NIC. The impact of the NIC is also visible through the number of institutions and individuals that have started to collaborate. Due to the fact that the NIC is still new, interviewees have sighted a need to market the NIC more vigorously.

5.3.4 Rating of participation in the Innovation Fund

Innovative ideas of high quality usually come from the previously white institutions. The structure of institutions (black versus white) is different. The previously white institutions usually have support and resources to look for the different funding opportunities that are

available. In particular they have dedicated individuals who also give support in terms of monitoring the closing dates, adherence to the requirements, etc.

“The HDIs, on the other hand, usually have people doing everything and therefore miss out on some funding opportunities that they would have benefited from”.

“In the past two years, when we have run the NIC, many HEIs were in the process of fairly intense re-organisation due to the mergers that have taken place. This was a significant factor preventing some from participating. A further factor is what is mentioned above, namely capacity within the HEIs to promote and foster innovation. Thus some participated in the first student business plan competition, gave the second one a miss, and are now eager to participate again since in two years they have a new crop of students with novel ideas that could be entered into the competition.”

These people usually do not have knowledge of how to look and where to look for opportunities.

5.3.5 Components of a good quality business plan and a poor quality business plan

A good quality business plan that will be able to win in the NIC should demonstrate a business case with commercial and market viability. Some form of market research must have been done to demonstrate that there is a market for the product. Some indication or commitment from the potential buyers of the product is an added advantage, particularly in the South African scenario, which relies heavily on imports of technologies and equipment. It should also be noted that the type of R&D and its products are determined by foreign countries where the investors are based. Other aspects to be considered are the competitive costs of production as well as cheaper pricing. For technology innovation competitions, business plans differ from other business plans in that they have to include a component of innovative technology. They should also accommodate the fact that the product is new and unknown and that there therefore are no market barometers to measure whether the product will be a success or not. In this case the market has not been tested as is the case with other products. Other aspects to

be incorporated in a business plan are market analysis, which includes the size of the market, role players, competitors, growth prospects, etc., financial projections and an estimate of expenditure and income, as well as overhead costs. It should also show how other funds will be raised (either through equity or through bank loans). A risk assessment of the business should also be provided as well as prospects for future technology innovation.

Some general criteria for a good business plan as expressed by interviewees are the following:

- A well-articulated 'value proposition', *"in other words an elevator pitch where in a few sentences the plan articulates the need being addressed, the approach proposed to address that need, the benefits of that approach as compared to competing approaches/products and what competing products exist"*.
- A sound team with the experience and track record to execute the plan.
- A sound 'route-to-market' strategy, *"i.e. a strategy for rolling out the product with respect to where it operates into the relevant value chain and how the market will be accessed in the context of that value chain, including the market mix (price, partners etc.)"*.
- Well motivated financials *"at a minimum a pro forma income statement indicating all assumptions on income and expenditure over a pragmatic timeframe"*.
- Evidence of market need/interest, *"ideally a letter form a potential customer indicating that a product with 'abc' features available for 'x' price in Rands will result in them potentially ordering 'y' products"*.

A poor quality business plan does not demonstrate the elements of a good quality business plan. A poor plan has no commercial and market potential, no competitive strengths, is irrelevant to the market, has no justification for investment as well as unrealistic payback periods and no demonstratable business case. A poor quality business plan :

“does not convincingly convey the key aspects identified above, as well as one where loose, unsubstantiated assertions are made about the product and/or business, e.g. ‘this is a world-class technology, a world first’ without evidence to support same”.

From the interviews it became clear that there is a need to assist in the development of business plans, particularly at the HDIs, because they do not have financial and human resources dedicated to the development of business plans and to source funding. Usually the innovators have no knowledge of the target market and have no experience in running a business. They also do not have any financial resources to invest in the business. From the interviews it also became clear that in order to succeed in the market for new innovations, a careful market analysis is required. This should include the projected market for the product, potential growth for the product as well as competitors.

5.3.6. Support systems and monitoring mechanisms provided by the National Innovation Competition to the successful institutions

A dominant view from the interviews is that the NIC provides funding and possible development of a database that constitutes best practices and success criteria as a guideline. The NIC provides funding and various other forms of support: It provides an opportunity for the participants and the winners to be part of a network in discipline, it provides an opportunity for collaboration and also provides patent support and guidance on patenting. Funding provided is in the form of seed funding from idea to concept proofing and prototype.

“Funding is very helpful and the assistance with information on marketing and patenting.”

The NIC works through the HEIs to provide support to students, in that seminars/workshops are arranged by the HEIs to assist in the drafting of business plans. Templates and guidelines to assist students are also provided. “This mechanism will hopefully be beefed up through resources and funds allocated.”

5.3.7 Mechanisms provided by the National Innovation Competition to encourage further participation in the Innovation Fund

The IF reviews the business plans, and where such plans fit within its mandate and criteria, applications are invited to other funding instruments. Such applications then proceed through the normal assessment/evaluation processes.

The following have been cited as mechanisms to encourage further participation in the IF:

- Seed funding for good innovations, which assists in financing the initial requirements of conception and testing the idea
- Incentives, such as support with regard to patents
- Market opportunities, particularly the linkages with interested buyers as well as possible international networks
- International collaborations through markets and other institutions
- Road shows to publicise the NIC

The main awards event is also meant to attract future participants and is an information-sharing session.

“The prize money is helpful but they should be more flexible with regard to the conditions that are attached to the prize. The conditions restrict the winners to use the money for certain things and not for others, which limits the scope of further development of the concept.”

5.4. CONCLUSION

It can be concluded that the South African NSI has embraced the concept of academic entrepreneurship as a vehicle to improve innovations at the level of HEIs. Academic entrepreneurship in South Africa is driven by the NIC, which is one of the IF's funding instruments. The impact of the IF within the NSI is acknowledged, particularly its role of providing funds for innovative ideas with potential. However, its impact has not been uniform across the whole spectrum of participants in the field of innovations. Beneficiaries of the IF are mainly drawn from private sector companies, science councils and a small number of the previously white academic institutions. Participation of the HDIs has been very minimal. This skewed participation can be attributed to the fact that HDIs do not have dedicated resources to focus on proposal writing in order to access the funds. The NIC was introduced to encourage HEIs to participate in technology innovations. The major impact of the IF has been the provision of financial support for innovative ideas from inception until the level of marketable products. However, a gap has been identified in the South African system, which is viewed as inhibiting innovations. This gap is the fact that HEIs are often forced to choose between basic research and applied research due to the DoE's current funding formula. It is important to note that this is not a unique situation in South Africa. The NIC was introduced to encourage academic institutions to become more innovative. This is done through providing incentives to students as well as HEIs. The uptake of the NIC is fairly good, judging by the number of TTOs that have emerged in the HEIs. These TTOs have emerged from both the HDIs and the previously white institutions. One of the successes of the NIC is seen through the change in the mindsets of participants and their roles in the innovation cycle. The NIC has also been successful in encouraging collaborations among researchers, and has created awareness about the commercialisation of innovations and issues related to intellectual property and patenting.

Chapter 6

CONCLUSION

This was in essence a descriptive research study that focused on the point that most developed countries recognise that it is important to incentivise innovation through various instruments. These instruments include the stimulation of innovation at universities. In this study it has been demonstrated that the countries reviewed are all committed to employing various innovation-specific interventions in order to encourage more innovations that will hopefully translate into economic growth and development. Usually if left to the market forces, technological innovation does occur, but not at the rate expected by policy makers. More often than not if technological innovation is left to the market forces, it does not address the needs identified by the policy makers such as economic growth, job creation and skills development. To encourage technological innovation and to ensure that this is aligned to policy objectives, different countries have introduced various incentive measures. Ultimately, the goal of these initiatives extends beyond the quantitative growth of the R&D enterprise. It also seeks to stimulate technological innovation and to ensure that more efficient application, commercial and otherwise, of the knowledge generated by the nation's R&D networks translates to economic growth.

Some incentive schemes implemented in the various countries have been discussed in this research report. Special attention has been given to those incentives that encourage technological innovations at academic institutions as well as those that link academic institutions with industry. As shown by the selected examples from the different countries, incentives schemes in general have a positive impact on the promotion of academic entrepreneurship. Academic entrepreneurship has been defined as “[the] variety of ways in which academics go beyond the production of potentially useful knowledge and undertake a variety of initiatives to facilitate the commercialization of that knowledge, which means they become active participants in designing new marketable products and take some sort of leadership role in ensuring successful commercialization” (Henrekson and Rosenberg, 2000:1).

There is also a positive relationship between these incentives schemes and the rate of patents from these technological innovations, as shown by the examples extracted from the Brazilian case study. The particular case from Brazil has demonstrated linkages between incentives to encourage academic entrepreneurship and the development of small to medium enterprises. This has led to the creation of start-up companies as well as the marketability of innovative products.

The Finnish case study provides a good example of best practice in which government interventions and incentives have led to increased innovations. A survey conducted by Meyer (2004) has shown that the incentives and funding mechanisms to academic institutions and entrepreneurs in Finland have had a positive influence in increasing patents. Most patented inventions from academic institutions in Finland are used by large and established small- and medium-sized firms. This survey also shows that the commercialisation of academic inventions in start-up companies is above the expected value in life sciences and below the expected value in engineering and materials science as a result of a lack of demand for technologies developed in the engineering field.

Despite the successes generated as a result of the incentive schemes, there are unique challenges faced by developing countries in creating a conducive environment for innovations. These challenges include regulations and patent issues, especially as most economies are opening up to international collaboration. A lack of patent legislation may leave these countries vulnerable to exploitation by external and more technologically advanced countries. Another challenge faced by both the developed and the developing countries is the expectation that universities will play a dual role in innovation, namely that they will focus on teaching and producing publications as well as producing cutting-edge technology inventions that will generate income in the market (Henrekson and Rosenberg, 2000:1). The nature of the requirements set to academic institutions often force academic staff to focus more on teaching and publishing instead of technological innovations and patents. The reward system is also more favourable towards teaching and publishing, instead of patenting. Some academics find teaching and publishing more attractive than technological innovations, which usually takes longer to reward the innovator.

With regard to the S&T system in South Africa, it can be argued that the South African S&T system was affected negatively by the isolation imposed as a result of racial segregation. The backlog and challenges that the current government are grappling with is a direct result of apartheid. These challenges include poor performance of the system and low investment by government in R&D. In general, South Africa faces a challenge in the field of human resources, which is extreme in the field of S&T. As a result of insufficient human resource capacity in S&T, the South African S&T system is overstretched at the human resource level. This is exacerbated by the fact that more than half of scientific articles are published by authors over the age of 50. South Africa does not have enough scientists per million of the population to be competitive with other similar-sized countries in the world. As a result of these challenges, the regeneration of the research workforce has been recognised as a high priority by government.

Despite the problems brought on by isolation, the South African S&T system became strong in some fields such as plant and animal science, biodiversity, some fields in medicine, astronomy and astrophysics, mining engineering and a few others. Although the new institutional and legislative framework is geared to meet the challenges of the S&T system in South Africa, very little improvement has been achieved, particularly in the field of innovation. To spearhead innovations, the IF was introduced in 1998 and has recorded major successes. However, a blockage has been identified at the level of HEIs, as shown by the amount of funds allocated to HEIs by the NRF to stimulate innovations (cf Table 3 in Chapter 3). Based on the allocation of funds to HEIs by the NRF, it can also be argued that the IF has not been adequate to stimulate innovation, particularly at HEI level.

The NIC was introduced in 2004 to unlock the blockages to innovation at HEI level through encouraging innovations and marketing the products while also looking for sponsors of the projects. The activities of encouraging innovations are usually housed under TTOs at HEIs. This is a growing trend internationally which South Africa is also following. The interest in the NIC is evidence of this growing trend. Although the NIC is new in South Africa, one of the research aims of this study was to look at its success as well as areas of improvement.

Despite the growing trend of using TTOs to stimulate innovations at HEIs, it is important to note that the findings of this study indicate that some of the TTOs are not effective because of poor financial and human resource capacity. It may be of worth to investigate models suitable for South Africa of providing sufficient resources to TTOs. In addition to this, it is also important to note that among the innovation schemes that have been investigated in this study, there are very few innovation competitions. This may be worth investigating through further research.

As reflected from the interviews conducted, there is general consensus that the IF has assisted in creating a culture of innovation and partnership in South Africa, in line with the international trend of academic entrepreneurship. However, because of the unique challenges inherent within the South African NSI, not all sectors have benefited through the IF. A sector that has remained behind in innovations is the HEI, which is of great concern to the policy makers. To resolve this problem, the NIC was introduced in 2004 to specifically target students and HEIs. Because of the newness of this competition it is difficult to measure its success with accuracy.

However, visible benefits mentioned are both the financial and non-financial incentives provided by the NIC. Some of the tangible effects are the following:

- ❖ Financial incentives
- ❖ More collaboration among researchers
- ❖ Awareness of commercialisation
- ❖ Awareness of patenting, intellectual property rights and marketing
- ❖ Emergence of TTOs across the HEI spectrum in South Africa
- ❖ Opportunities for participants to be part of the network of the discipline of innovators
- ❖ Shifting focus from big ideas to students, thereby building the capacity for future innovators and researchers

The opportunities and exposure to the markets and potential investors have been cited as some of the benefits. Putting together a convincing business plan has been cited as a key to succeed in winning the NIC. A proposal made during the interviews is the availability/creation of a database for all the previous participants and model business

plans for the prospective participants to use as a benchmark. A concern raised, particularly by the participants and winners, is the restrictions imposed on the use of the prize money, which is viewed as inhibiting the use of the money to further develop the concept.

Other remarks made during the interviews illustrate the lack of a culture of research in the academic institutions, particularly the HDIs, as a result of pressure from both the students and academic staff. The students find themselves under pressure to complete their studies in the shortest possible time to earn a living to support their families. The academic staff, on the other hand, is under pressure to produce numbers of graduates to meet the targets of academic institutions. As a result of these pressures, research and technology innovations are not seen as a priority in some academic institutions. Consequently, opportunities presented through incentive schemes such as the NIC are sometimes not taken into consideration and therefore may be underutilised. One hopes that in future more effort will be made by academic institutions to exploit these opportunities. This is viewed as a responsibility of both the NRF to market the NIC and the academic institutions to encourage and support students to participate in the NIC.

Other insights from the interviews highlighted the dilemma linked to the historic challenges in South Africa presently, particularly in the S&T sector, namely the number of matriculates who qualify to take up career choices in the fields of S&T. A view was expressed that this is one of the areas that needs to be addressed urgently. This needs to be addressed in an integrated manner by all stakeholders in the S&T system and the education sector.

Another point of emphasis is related to the lack of co-operation between the DoE and the NRF, particularly with the current funding framework, which measures and rewards academic success by the number of student enrolments only, instead of research outputs as well. This indirectly puts pressure on academic staff to concentrate their energies on teaching students instead of conducting research and other innovative activities, as their outputs are measured according to the number of enrolments. The reward system tied to research outputs is also slow as research results tend to be visible only after a few years. This is viewed as a major contributor to the poor research culture in some academic institutions.

None of the interviewees mentioned joint initiatives and international collaborations. This is regarded as a gap within the NIC; which needs to be addressed. A new initiative with international partners may have to be considered. This will assist students and academic institutions to work with international partners and learn from international best practices. It will also assist in collaborative research outputs such as co-authorships with international partners, which will improve South Africa's publication records. A multi-pronged approach is required to address these challenges instead of a piecemeal approach that is currently used in the South African NSI.

Another view cited prominently by interviewees is the value of money offered to the winning students and the winning institutions. Although the money is appreciated, there is a view that it is not adequate to cover future initiatives to build on the winning concept and to market it. The costs of putting together these initiatives can be very high for students and academic institutions. The NIC needs to consider increasing the prize amounts to make the competition more attractive. Again, in this instance, international best practice should be considered to investigate suitable prize amounts. Costs of putting together a winning concept (such as time and other inputs) should be considered in determining the prize amounts.

More attention needs to be given to interested academic institutions and students to draft winning business plans. Drafting business plans is viewed as a laborious process by some of the previous participants, particularly those who have not received support and mentoring from some higher authorities within the particular academic institutions. The idea sighted during the interviews of creating a database of model business plans needs to be considered. In addition to the database, some form of a support group, particularly from the previous winners, needs to be established. This group will act as mentors of the new entrants and also provide some technical and moral support to the prospective participants.

As this field of academic entrepreneurship is a fairly new area of research in South Africa, the formation of the support group will act as a point of reference and source of information for future students who wish to further their studies in the field of academic entrepreneurship. The researcher's experience is that there is minimal secondary

information available in this field in South Africa. This adds more pressure within the reserchers for information to be gathered through primary research. The fact that the NIC only started in 2004 means that it is not possible to have a large pool of people to interview in an attempt to gather detailed information on this subject in South Africa.

Linked to this fact is the high mobility of staff within the field of academic entrepreneurship and TTOs, which is viewed as one of the challenges in building a cadre of expertise in this field. Sadly most of those who started the process in 2004 when the NIC was launched have joined other institutions in search of better opportunities. This is attributed to a number of factors. Key among these factors is the reality that most of those who were part of the process in 2004 were students at that time and have therefore naturally moved to permanent employment elsewhere. One would hope that those students who had an interest in innovation competition in 2004 would be employed and retained by academic institutions and supported to harness those ideas that made it to the NIC. Regrettably, as discovered during the process of gathering information and searching for interviewee candidates, most of these students have joined the private sector and most of them are no longer pursuing innovation activities in their careers. It is important that some effort is made jointly through the NIC and academic institutions to retain such talent within the S&T system.

In addition to the high mobility of previous NIC participants and personnel within the academic entrepreneurship field, a gap has been identified, particularly in the HDIs, of a need to establish dedicated capacity to mobilise students to participate in the NIC. This requires both human and financial resources. This capacity will also tap into the opportunities that are offered by institutions such as the EU for joint projects with African researchers. It is important to note that as HDIs embark on these initiatives, proper education on matters of intellectual property rights will have to be undertaken.

In general, this report concludes that globally academic entrepreneurship presents a bright future for innovations at HEIs. The study has also demonstrated that the concept of academic entrepreneurship is embraced by the HEIs in South Africa. Furthermore, it has demonstrated the existence of a positive relationship between economic development and innovations. The critical role that HEIs play in innovations has been acknowledged. The innovation incentives that are currently available in South Africa,

which are meant to encourage innovations as a driver of economic development, have also been outlined. The newly established NIC, which focuses specifically on innovation incentives for HEIs, is one of the initiatives. The report indicates that the NIC centres on student ideas, which is viewed as the future of innovations at HEI level. This is an attempt to invest in the future innovators by identifying talent at the level of students. The concept of academic entrepreneurship is well received within the HEIs, as seen by the number of TTOs that has emerged across the country. However, some measures are needed to discover more innovators from HEIs. Most importantly, it is critical to devise mechanisms of keeping the newly discovered innovators within the community of innovators. This will help South Africa to develop a cadre of innovators. It will also help to ensure that innovative ideas are developed to a level of marketable products as well as the level of patenting. That is the only way for HEIs to reap economic benefits from their innovation efforts.

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8. APPENDIX 1: LIST OF PEOPLE INTERVIEWED

1. Dr Philemon Mjwara: Director-General of the DST
2. Dr Adi Paterson: then Deputy Director-General responsible for Science Expert Services, DST
3. Mr Dhesigen Naidoo: then Deputy Director-General responsible for International Co-operation and Resources, DST
4. Mr Steven Ratsatsi: Senior Manager responsible for the IF, DST
5. Ms Ela Romanowska: Seed Fund Manager, NRF
6. Dr Rudi van der Walt: Director of Innovation, the North-West University (also winner of 2004 NIC).
7. Prof Steyn: Stellenbosch University
8. Prof Thomas auf der Heyde: Director of Research and Innovation at the University of Johannesburg
9. Mr JP Klopper: Manager: NIC, NRF
10. Mr. Jan Mentz: then Head: Contracting and Intellectual property, University of Pretoria

9. APPENDIX 2: INTERVIEW SCHEDULE

- a. What would you regard as the most important effects of the Innovation Fund on the National System of Innovation?
- b. Have these effects been uniform across the system or different for different institutions?
- c. What do you view as the main purpose of the Innovation Fund?
- d. What should its main goals be?
- e. Have these goals been realised? If so, how?
- f. How do you rate participation in the Innovation Fund? Which institutions participate better and for what reasons?
- g. What constitutes a non-winning business plan?
- h. What support systems and monitoring mechanisms does the NIC provide to the winning institutions?
- i. What mechanisms does the NIC provide to encourage further participation in the Innovation Fund?