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THE IMPACT OF POLICY ON TECHNOLOGY

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THE IMPACT OF POLICY ON TECHNOLOGY CAPABILITY IN THE GAUTENG INNOVATION HUB

By

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Submitted in fulfillment of the

partial requirements for the degree of

M. P & D. M. (Master of Management)

in the

Graduate School of Public and Development Management.

University of the Witwatersrand

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C O N T E N T S

DECLARATION i
ABSTRACT ii
DEDICATION iii
ACKNOWLEDGEMENTS iv
LIST OF ACRONYMS v

CHAPTER 1: BACKGROUND AND CONTEXT

1.1 Introduction 1
1.2 Background and Context 2
1.2.1 The Innovation Hub as a Catalyst 3
1.2.2 Maxum: The Hub of Building Technology Capability 5
1.3 Conceptual Framework of the Study 7
1.3.1 Technology Capability 7
1.3.2 Policy Relevance to the Study 8
1.3.3 Evaluation of Impact 10
1.4 Research Scope and Rationale 11
1.4.1 Problem Statement 11
1.4.2 Purpose 13
1.4.3 Limitations 14
1.5 Chapter Outline 15

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction 17
2.2 Understanding Technology and its Dynamics 17
2.2.1 Defining Technology for Understanding Technology Innovation 17
2.2.2 The Empirical Illustration of Technology Innovation 19
2.2.3 Forms of Technology Innovation and Bearing on Technology Capability 20
2.2.4 The Implications for the Maxum Incubator 24
2.3 Perspectives on Technology Capability Factors 26
2.3.1 The Role of FDI in Technology Capability 27

2.3.2 The Role of R&D in Technology Capability 32
2.3.3 The Role of Human Capital Development in Technology Capability 38
2.4 Critical Observations for Analytical Framework of Innovation Hub 41
2.5 Concluding Remarks 44

CHAPTER 3: RESEARCH APPROACH AND METHODOLOGY
3.1 Introduction 45
3.2 Research Approach 45
3.3 Research Methodology 48
3.3.1 Nature of Research Methodology 48
3.3.2 Research Population 49
3.3.3 Data Collection 50
3.3.4 Data Collation and Analysis 50
3.3.5 Limitations of the Research Methodology 53
3.4 Conclusion 53

CHAPTER 4: PRESENTATION OF THE FINDINGS
4.1 Introduction 55
4.2 Data Presentation and Findings 55
4.2.1 The (start-up) Enterprise Technology Status 57
4.2.2 The Policy Environment 62
4.2.3 The Maxum Incubator as a Technology Capability Building Agency 65
4.2.4 The Importance of Technology Capability Factors 68
4.2.5 Impact Evaluation 71
4.3 Summary of the Key Findings 72
4.4 Concluding Remarks 76

CHAPTER 5: ANALYTICAL INTERPRETATION AND CONCLUSIONS
5.1 Introduction 77
5.2 Critical Examination of the Findings and Propositions 77
5.3 Conclusions 80
5.4 Concluding Remarks 84

CHAPTER 6: RECOMMENDATIONS

6.1 Introduction 85

6.2 Recommendations 85

6.2.1 The Global Resource Impact Evaluation 86

6.2.2 The Business Cluster Formation 86

6.2.3 Industry/Sector Specialisation 87

6.2.4 Promotion of Indigenous Technologies 88

6.2.5 Enhancement of Legal Support Services 89

6.2.6 Institutionalised S&T Linkages 89

6.3 Concluding Remarks 90

BIBLIOGRAPHY 91

ANNEXURES

Annexure A: Primary Research Questions 94

Annexure B: A List of (start-up) Enterprises still in the Maxum Incubator 100

DECLARATION

I declare that the report

THE IMPACT OF POLICY ON TECHNOLOGY CAPABILITY BUILDING THROUGH THE GAUTENG INNOVATION HUB

is my own unaided work. It is submitted in partial fulfillment of the requirements of the degree of Master of Management (in the field of Public and Development Management) at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other university.

_____

Signed
Maredi, S A. (Mr)
30th day of April 2006

ABSTRACT

When South Africa was welcomed back into the community of nations, one of its biggest challenges was to compete economically, and this required the development of its technology capability. As part of the new policy direction, the development of the Small and Medium Enterprises (SMEs) and the role to be played by them were promoted. To this end, government-sponsored science parks or technology incubators, such as The Innovation Hub, were established to facilitate and stimulate technology innovation and commercialisation.

This research study attempts to illuminate the extent to which policy created a conducive environment for technology innovation, diffusion and capability. It also examines the factors purported to drive technology capability in order to depict their role, both individually and collectively, in stimulating technology capability. It assesses the "impact" made by The Innovation Hub through the Maxum Incubator on technology capability of the start-up enterprises. The international experience in this regard proves that there is in fact no universally applicable strategy to attain technology capability, and that the applicability and success of the strategies depends to a large extent on the peculiarities of the countries and the management thereof. This is supported by the diversity of theoretical and empirical models of generating the necessary S & T knowledge.

The data, findings, analytical interpretation of these, and the conclusions, all demonstrate that the technology capability factors have played a symbiotic role in the attainment of the enterprises' technology capability. In view of the relative "impact" made by The Innovation Hub in this respect, the final recommendations (such as comprehensive Monitoring and Evaluation systems) are aimed at maximizing the "impact" that The Innovation Hub or similar incubators is able to make.

DEDICATION

My heartfelt gratitude goes to my late father who always wanted me to be the best, despite my visual impairment; and to my loving mother who has always seen me as the light in the family. Though you might not have had any formal education, let alone literacy, your motivation has been extraordinary.

May the amount of hard work that went into this research study serve as inspiration to my 6-year-old daughter, Tswelopele, to be the best that she can be in her life.

ACKNOWLEDGEMENTS

I heartily thank Dr. Thomas Mogale for encouraging me, for his valuable comments, advice and for guiding me through this task. Many thanks are also due to Martin Manmohann, Operations Manager at The Innovation Hub, who was generous with his time and in ensuring that the research population was co-operative when it mattered the most.

Colleague Busisiwe Nyembe is greatly thanked for helping with the preliminary layout of the document and its presentability.

ACRONYMS

AA	Affirmative Action
ADA	Americans with Disability Act
AMTS	National Advanced Manufacturing Technology Strategy
ASEAN	Association of South East Asian Nations
BEE	black economic empowerment
CRT	contract research and technology
CSIR	Council for Scientific and Industrial Research
DACST	Department of Arts, Culture, Science and Technology
DST	Department of Science and Technology (since July 2002)
DTI	Department of Trade and Industry
FDI	foreign direct investment
GDP	gross domestic product
GPG	Gauteng Provincial Government
IASP	International Association of Science Parks
ICT	Information and Communications Technology
IF	Innovation Fund
IMS	Integrated Manufacturing Strategy
IPR	Intellectual Property Rights
LCD	liquid crystal display
M&E	monitoring and evaluation
MNC	multi-national corporation
NAMAC	National Manufacturing Advisory Centre
NBIA	National Business Incubation Association
NIC	newly industrialized country
NPDC	National Product Development Centre
NRDS	South African National Research and Development Strategy
OCR	optical character recognition
OECD	Organisation for Economic Co-operation and Development
PFMA	Public Finance Management Act
R & D	research and Development
SDI	Spatial Development Initiative
SERA	Southern Education Research Alliance

SET	Science, Engineering and Technology
SME	small and medium enterprise
SPII	Support Programme for Industrial Innovation
S & T	science and technology
TEP	techno-economic paradigm
TNC	trans-national corporation
UK	United Kingdom
WPST	White Paper on Science and Technology

CHAPTER 1
BACKGROUND AND CONTEXT

1.1 Introduction

With the democratization of South Africa in April 1994, the country was confronted with the enormous challenge of repositioning itself to play a more meaningful role in the global economy. Internally, the country was marred by the far-reaching impact of socio-economic inequalities such as a skills deficit, partly the result of its prolonged political isolation. These inequalities had to be redressed in order to create the necessary capacity for such a repositioning to happen. Externally, the country's inevitable challenges were made more complex by the "competitive" nature of the global activities between the economically advanced and the less- or non-advanced nations, as well as those in transition. One of the underlying dimensions of this global "competitiveness" has been "to keep pace with and perhaps occasionally overtake the pack of competitors", whilst the competitors themselves also "develop strategies which will give them flexibility to move into a controlling position at various stages of the race" (Georgiou et al., 1986, p.1, in Chang, 1998).

South Africa is neither the only, nor the first, country to grapple with the challenges of an increasingly competitive global economy. The need for the state has not simply been to draw on essential lessons from other countries, but equally importantly, it has had to adapt international best practice to local conditions, and formulate an appropriate response to local market realities. These approaches all require an in-depth mastery of the global economic system itself. An essential part of such an understanding is, primarily, to appreciate that the economic capacity and competitiveness in the global environment have to a considerable extent been measured in terms of the innovation, development and commercialisation of technology and the capability of the technologies developed. Simply put, technology innovation and the commercialisation thereof are key factors for success in global economics, and they are referred to elsewhere in this study as "technology capability".

Given the growing interest in the concept of technology capability, the aims of this chapter are to:

- Introduce and define the key concepts underlying the research topic, namely, technology capability, policy and impact;
- Create the context and conceptual framework for common understanding and critical analysis/interpretation of the economic and development issues at stake; and
- Provide the context for The Innovation Hub as the catalyst for socio-economic development in Gauteng.

1.2 Background and Context

Knowledge-intensive, high-technology industries are increasingly becoming the most critical and strategic industries for economic survival and growth in the world's economies. Venturing into technology is thus becoming an important force in global businesses and economies, as developed and developing nations pursue policies and measures that encourage business ventures to accelerate national economic development. This is attested to by the significant growth worldwide in the numbers of science parks and technology incubators, an important strategy to facilitate technology innovation and transfer through the concomitant creation of venture businesses. A critical component of technology venturing is in general technology transfer or the commercialisation of technology, knowledge and ideas. In short, the main objective of the science parks and incubators, as a technology innovation and transfer strategy, is "to promote the application of science by bridging the gap between research and development (R & D) and commercialisation" of the technology innovations, referred to previously as technology capability (Sung et al., 2003).

Like many other countries that are keen to develop economically, South Africa has adopted an approach which assumes that the ability to adapt to change, to recover from the effects of the past socio-economic inequalities/crises and achieve a vibrant economy is largely dependent on appropriate policies. Such policies should recognise and support technology innovation and transfer, particularly through promotion of the small and medium enterprise (SME) sector linked to other sectors of the economy. The government's appreciation of global economic competitiveness and its dynamics was documented in the Department of

Arts, Culture, Science and Technology (DACST) Strategy as early as 1996. To give but one example, the document confidently maintains that: "Our science and technology provide us with a solid foundation from which a national economic and social renaissance can occur in our new democracy. The challenge to us is not what science and technology can do for us as a nation, but how we should use and manage science and technology for the common good of the people" (Foundation for Research Development, 1998).

To this end, the South African government embarked on a new macro-economic development policy focusing on the areas of technology, value-added manufacturing, transport and tourism. One of the translations of this new macro-economic development policy into a national programme is the Spatial Development Initiative (SDI) programme, which was in turn translated by the Gauteng Provincial Government (GPG) into a concrete mega-project focusing largely on technology, and known as The Innovation Hub.

The Innovation Hub was established by the GPG as a partnership with Blue IQ and the Southern Education Research Alliance (SERA), and a strategic alliance between the Council for Scientific and Industrial Research (CSIR) and the University of Pretoria in April 2000. It began operating as a pilot in October 2000 and subsequently registered as a public company in September 2001. Its shareholding was transferred from CSIR to GPG. Further reflecting its public company nature, The Innovation Hub is subject to the requirements of the Public Finance Management Act (PFMA). In compliance with Section 66 of the PFMA, the board decides the funding requirements of the company, and the annual financial statements are prepared and audited in accordance with Generally Accepted Accounting Practice.

1.2.1 The Innovation Hub as a Catalyst

Like many other international incubators that nurture young firms, helping them to survive and grow during the start-up period when they are most vulnerable; The Innovation Hub was established with the sole business purpose of supporting "the creation, nurturing, growth and globalisation of technology-led and innovative entrepreneurs and business enterprise" (Annual Report 2001/02, p.2). In essence, The Innovation Hub serves as the point of intersection between ideas and action, between research and development, between innovation and entrepreneurship with the aims of:

- Unlocking the country's economic potential in chosen areas, particularly economic renewal in Gauteng;
- Proactively stimulating high-tech business growth and development of the required skill base; and
- Striving to attract and stimulate venture capital (Annual Report 2002/03, p. 15).

In short, The Innovation Hub is claimed not only to symbolise South Africa's gateway to the fast-moving international world of technology as echoed by Bagus (1999), to mention but one author, but is, interestingly, also expected to spearhead the development of technology entrepreneurship in Africa.

Sung, et al. (2003, p. 450) claims that the success rate of venture businesses worldwide can be as high as 50%, if adequately supported by government, universities, research institutes, and other related institutions. The strategic location of The Innovation Hub in Gauteng must have been influenced by a similar, yet also historically informed, premise. For example, since the discovery of gold in the Witwatersrand, Gauteng – "The Place of Gold" – has been the engine of South Africa's development into a modern industrial and technological nation (www.innovationhub.co.za). Although it is the smallest province in the new dispensation, it still optimally generates 38% of the country's economic output and 10% of that of Africa. It represents 70% of the total formal employment, and currently employs over 80% of high technology workers in South Africa, creating the highest demand for an electronic and information technology (IT) expertise in Africa (www.innovationhub.co.za).

In addition, the Gauteng Province has a well-developed tertiary education sector that complements its economic base. It comprises 40% of all university enrolments in the country. Its tertiary education sector produces 40% of science graduates and 44% of engineering post-graduates. Gauteng also hosts the greatest concentration of research activities in the country, including science councils and industrial R & D facilities (www.innovationhub.co.za).

The advantageous capacity and potential of Gauteng is dependent on the relatively available and advanced knowledge infrastructure, when compared to the other provinces. This situation has earned the province the status of being the epicentre of Africa's political,

technological and economic activity. In the long run, it seems likely that The Innovation Hub will contribute to positioning Gauteng as the "smart" province and, in turn, optimising socio-economic development for the country. The success of The Innovation Hub is also, to a considerable extent, dependent on the socio-economic capacity and potential of Gauteng. Each of these two aspects feeds on and in turn stimulates the other.

To clarify its strategic geographical location: The Innovation Hub is located in Gauteng, South Africa, on a unique research/education knowledge axis between the CSIR and the University of Pretoria. It is adjacent to the N1 highway, and in close proximity to the corridor to Johannesburg and the Johannesburg International Airport. It is strategically situated to interface with the country's best universities and research institutions, and to provide easy access to the networks of markets and distribution channels.

1.2.2 Maxum: The Hub of Building Technology Capability

The years of planning and policy-making have been characterised by an understanding that there must be a shift in emphasis from large-scale enterprises to the SME sector. This included a greater recognition of the significant role that SMEs can play in achieving national development goals as articulated in the White Paper on National Strategy for the Development and Promotion of Small Business in South Africa (1995). In this paper, the technology venture businesses are referred to as technology "start-up" enterprises. These start-ups are more often seen as a pathway to the formation of small and medium enterprises. Strictly speaking, the promotion of the "start-ups" is a strategy to develop the SMEs. Of great importance in this regard is the point made by Simpson (1999) that, internationally, SME development can be found to contribute to any or all of the following objectives, which are very similar to those of South Africa's White Paper on National Strategy for the Development and Promotion of Small Business in South Africa (1995):

- Promoting national and regional economic development goals;
- Promoting employment, particularly in creating new jobs;
- Alleviating poverty and assisting those who are disadvantaged; and
- Promoting equity and addressing uneven development.

As part of the strategy to develop technology capability, The Innovation Hub provides a three-phased Maxum Incubation programme to a sizeable number of innovative start-up companies. The programme, which resembles most of the international technology business incubation features in many respects, is divided into pre-incubation, incubation and post-incubation phases. For example, the programme, like the Malaysian model, is largely focused on "entrepreneur development" at an entry level. In this regard, the potential entrepreneurs are assisted to develop innovative concepts, competence building, knowledge enhancement and skills upgrading. However, in the case of The Innovation Hub, the preferential focus is on stimulating the development of previously disenfranchised individuals, in order to better meet Affirmative Action (AA) and Black Economic Empowerment (BEE) requirements. This phase focuses on development of individuals/entities and/or start-up companies at their pre-production stage.

The second phase of the Malaysian model concentrates on "enterprise creation", which could possibly be assimilated into the incubation phase in the case of The Innovation Hub. In the main, this phase develops small enterprises by providing them with the opportunity to practice teaching/knowledge in a controlled environment. In articulating the main purpose of this phase, the Annual Report (2002/03, p. 19) explains that the purpose of the incubation phase is to stimulate and facilitate the growth and sustainability of knowledge-intensive and technologically innovative start-ups in a synergistic environment where entrepreneurs are sharing, learning, creating working partnerships and doing business together with the objective of spurring local economic development and commercialising scientific or academic findings. In simple terms, this phase concentrates on the companies ready to go into market testing and production stages.

The last phase is the "market development" which entails "the complete process of moving a technical concept through to its commercialisation". Put differently, this phase comprises the enterprises that graduated from the two previous stages, and in most instances still have some associate dealings with The Innovation Hub. Thus far, it could be argued that The Innovation Hub follows globally recognised procedures when building technology capability of the start-up companies. Therefore, the effect of the last two phases of the Maxum incubation programme constitutes the substance of this study.

1.3 Conceptual Framework of the Study

1.3.1 Technology Capability

In light of the backdrop outlined above, it becomes clearer that technology innovation is not simply central to, but is also a necessary condition for, technology capability. In order to reach a common understanding of the concept "technology capability", it is necessary to define "technology innovation". Such an approach is premised on a simple understanding that "technology innovation" is an integral part of "technology capability".

In this research report, "technology innovation" is used to refer to the process of successfully turning:

- A novel technical idea into a novel use;
- An already developed technical idea into a novel use;
- A novel technical idea to a familiar use; or
- An established technical idea to an established use where, previously, the attempt resulted in commercial failure (Georgiou, 1986, p.12, in Chang, 1998). Simply put, the essence of this concept presupposes provision of technologically and commercially based solutions.

Following this definition of "technology innovation", "technology capability" could therefore be defined as the continuously upgraded capacity and ability to produce a (new) product and/or provide a (new) service that competitively give(s) one country, industry or firm an economic and commercial edge over the others. The "building" thereof is used to refer to any conscious effort, coupled with support programme(s), to technically, economically and entrepreneurially capacitate a country, industry, firm or individual(s) to provide technologically- and commercially-based solutions. Therefore, "technology capability building" is used elsewhere in this research report firstly to refer to the building of appropriate competences to provide technologically- and commercially-based solutions to meet either national or business requirements. Secondly, it is used to refer to the promotion and development of a culture of innovation supporting the long-term sustainable development, economic growth and global competitiveness as attested by commercial gains (Annual Report, 2002/03, p. 4). The culture of innovation includes the reorganisation of work and/or organisational form for purposes of higher productivity.

1.3.2 Policy Relevance to the Study

In his 2002 address, the chairperson of The Innovation Hub, Mr Neo L. Moikangoa, like many other economic analysts, emphasised the importance of policy, making the point that achievement of sustainability through attraction of local and international investment is dependent on success in creating a favourable investment environment, as well as the adoption of policies that enhance, rather than impede, competitiveness (Annual Report, 2002/03, p. 5). Similar observations had earlier been made by scholars like Simpson (1999, p. 1) who postulated that policies should not simply demonstrate the directions, intentions and commitment of the government, but should also provide the justification and basis for legislative and regulatory action, thus illustrating the significance of policy in technology capability building. In setting the science and technology (S & T) policy direction for South Africa, the White Paper on Science and Technology (WPST) (1996) lists the following as the pertinent goals:

- The establishment of an efficient, well co-ordinated and integrated system of technological and social innovation;
- The development of a culture within which the advancement of knowledge is valued as an important component of national development; and
- Improved support for all kinds of innovation which is fundamental to sustainable economic growth.

The South African National Research and Development Strategy (NRDS) (2002, p. 5) confirms the status of the WPST (1996) as a robust and effective framework and makes the point that it is a strategy that "operates in the context of that policy to strengthen key elements of our system of innovation that have been identified as needing particular attention and focus." Some of the key weaknesses addressed in the NRDS (2002, p. 15) are:

- Ageing and shrinking human resources in S & T;
- Declining R & D in the private sector; and
- The fragmentation of government S & T.

In light of the indispensable significance generally associated with, and for purposes of systematic and common assessment of, the impact of "policy"; this research defines "policy" as "an articulation of basic principles", based on and in pursuit of choices between what "to do and not to do", and which are

- on the implementation level, further translated into specific concrete programmes/projects; and
- in turn linked to systematic "application of knowledge and reason" and strategic allocation and management of resources towards solving specific "problems" or attaining "specific goals and actions" (Dobson, 2002, pp. 244-5).

Within the context of this study, the South African macro-economic development policy represents the articulation of specific economic principles to pursue, as already alluded to. The SDI programme symbolises a concrete translation of the policy into implementation programmes. Most significantly, The Innovation Hub, and in particular the Maxum incubation programme, represents a strategic allocation of resources towards attaining "technology capability" of (start-up) enterprises.

This definition of policy presupposes a need for the following concomitant capacities underlying the essence of policy and its management:

- Political leadership and direction, that is, the political will to make and support clearly defined and targeted policy decisions responding to the specific needs, opportunities, challenges or constraints of the given time.
- Administrative capacity, that is, the capacity of the public sector to engage in policy formulation, implementation, performance management and review in support of the current views of government.
- Analytical capacity, that is, the capacity to accurately analyse trends in the environment, translate those into policy programmes/projects and allocate necessary resources accordingly.
- Co-ordination capacity, that is, co-ordination across all stakeholders and/or sectors for accomplishment of a common goal and avoidance of duplication, overlaps and gaps.

In sum, a conducive environment for technology innovation is not simply dependent on policy, but rather on an integrated harmonious policy framework and co-ordination and integration of programmes/projects across the social and economic spheres in pursuit of the given goals.

While it is still early in the process, there are increasingly encouraging signals indicating some success on the part of government towards economic recovery. The democratisation of South Africa and its legislative aftermath have been instrumental in creating a significant shift in the minds of politicians and policymakers. Key policy initiatives responsible for ushering in the enabling environment, particularly within the context of The Innovation Hub, include:

- The introduction of the new constitution in 1996;
- The shift from centralisation to decentralisation of government services and the empowerment of local authorities;
- The significant increase in the emphasis on the contribution of SMEs to national development, rather than a narrow focus on large-scale enterprises; and
- A repertoire of manufacturing, innovation and R & D policies/strategies published by various government departments/institutions, including, inter alia, DACST and the Department of Trade and Industry (DTI).

1.3.3 Evaluation of Impact

In this research report, the word "impact" is used mainly to refer to the ultimate desired change(s) in the general state and/or condition of (business) well-being. The change in this context represents the ultimate end in the form of, to mention but a few diverse examples, socio-political, technological and economic targeted results directly acquired from the implemented (public policy) programmes. In other words, the aggregated outputs and/or outcomes accrued from a particular programme may manifest a change. Following this definition, "impact" should therefore in the final analysis reflect a time-lag relationship between the original (government/programme) strategic priorities and their desired outcome(s) in the form of positive change, or possibly what are often referred to as (accomplished) goals (Warwick, 2000).

This can be expanded upon: in contrast to monitoring of projects, which only considers issues related to project activities, the evaluation of impact completes the project development cycle, and examines the "effectiveness" of a given project. Examples of "impact" include reduced poverty levels and globally competitive enterprises, whereas those of monitoring might include the number of skilled engineers or the number of funded projects in a given financial year. In comparison to outputs, which are usually captured through monitoring, these examples of "impact" are somewhat qualitative or abstract and often difficult to measure quantitatively.

"Impact" may also be influenced by a wide range of factors, which may not fall entirely within the control or accountability of one institution, programme or project. This suggests that the achievement of "impact" may inherently require the co-ordination and integration of several programme evaluations across different institutions. With this in mind, it may therefore be necessary to also examine both endogenous and exogenous factors when evaluating the "impact" of a particular programme.

1.4 Research Scope and Rationale

1.4.1 Problem Statement

As outlined above, the process of building technology capability has increasingly become a crucial strategy in dealing with the forces of the competitive global economy. In pursuit of this objective, countries put in place policies that create a conducive environment for the interplay of capital investment, R & D and human capital development (HCD). These are generally regarded as the key technology capability factors. Similarly, in South Africa, the concept of The Innovation Hub as a science park-type programme has been instituted to serve as the co-ordinating and integrating catalyst platform for the fertile interplay of these technology capability factors. The services related to such technology capability factors are provided in collaboration with the University of Pretoria and the CSIR. According to The Innovation Hub's Annual Report (2001/02, p. 9), to give but one example of the anticipated outcomes of the Maxum incubation programme, a science park stimulates and manages the flow of knowledge and technology amongst universities, R & D institutions, companies and markets. This point is confirmed by Sung et al. (2003) when making the point that the main objective of the science parks and/or incubators is most often to

promote the application of science by bridging the gap between R & D and commercialisation of scientific and academic findings.

However, in spite of its recent establishment, the complex responsibility it was assigned, and the time-lag that normally occurs between policy/programme implementation and outcomes/impact, The Innovation Hub had already by 2003 claimed several achievements which include, but are not limited to:

- Electrosoft, which scooped one of the eleven SABS Prototype Awards at the SABS Design Institute Awards for its total wireless phone shop product that can operate on solar power;
- Grintek, which acquired 30% of Expertron Group (Pty) Ltd (one of the first companies in the business incubator) and their registered innovative information security solution product Cell-ID which has been approved by the PCT patent office in Brussels;
- Vas-Tech (Pty) Ltd, which has signed an international distributor agreement with Spescom Data Voice for the distribution of its range of computer-based digital recording equipment; and
- The Naledi3D Factory, which was assigned by UNESCO to develop a virtual reality model for the Nakaseke Telecentre in Uganda that demonstrates basic hygiene principles to rural communities.

In addition, NRDS (2002, p. 14) makes a general, yet critical, point with regard to the achievements of The Innovation Hub. It acknowledges that the governance structures in the process of building technology capability are extremely complex, and are therefore resistant to strategic intervention by a single agent. Similarly, it is extremely challenging to objectively evaluate the impact made under such institutional arrangements, particularly within a short space of time.

Consequently, the core or thematic questions for analysis then become:

- To what extent do existing policies create the environment within which technology innovations, diffusion and capability can be enhanced?
- What is the impact of the Maxum incubator in The Innovation Hub on the technology capability of the technology (start-up) enterprises?

- What are the (set technologically competitive) indicators against which the (start-up) enterprises and/or The Innovation Hub evaluate their (own) technology capability and progress?
- How important has each technology capability factor (FDI, R & D and HCD) been in contributing to the (start-up) enterprises' technology capability?

Though these questions are interrelated; they are separated here for comprehensive and systematic analysis purposes. An underlying concern of these questions is: what is the significant impact made by The Innovation Hub as the policy implementation programme in securing the upgraded capacity and ability to provide technologically based solutions and to support long-term sustainable development which gives technology (start-up) enterprises an economic and commercial edge over their counterparts. There is a need to determine the (start-up) enterprises' prospects of engaging in new technology innovation and/or diffusion projects.

1.4.2 Purpose

The main purpose of this research is to critically evaluate the impact made by The Innovation Hub in stimulating and promoting technology capability through a co-ordinated and integrated interplay of investments, R & D and HCD for entrepreneurial and commercial purposes. On the level of sub-objectives, the research seeks to:

- Understand the extent to which policy is relevant in creating an enabling environment within which technology capability can be enhanced for global competitiveness.
- Understand the role of the Maxum incubator in The Innovation Hub on technology innovations, diffusion and capability.
- Contribute to academic literature on technology capability building through the science parks and/or incubation programmes.
- Disseminate knowledge of the innovation concept and promote debate around its effectiveness in South Africa.

The decision to focus this study on technology capability is informed by the importance increasingly associated with the concept of technological "innovation" and in particular the effects thereof on technology capability. In his articulation of the importance of

technology capability, Miyazaki (1995, p.19) maintains that if an enterprise is unable to sustain technology capability it will fail to keep up with the technology race. Its products will tend to lose competitiveness, even if it has other areas of competency, such as financial and marketing competency. Secondly, the introduction of this concept in South Africa, as elsewhere, involves the integration of various streams of expertise and effective mobilisation of resources across different institutions. Little is known of the inter-institution dynamics and their impact on the building of technology capability. Thirdly, given the limited information and knowledge around the innovation concept, this study seeks to disseminate the knowledge of the concept especially ahead of the 2008 international conference on science parks/technology incubators to be hosted in South Africa. Technology capability is a vitally important area that countries, industries and/or enterprises cannot afford to ignore.

1.4.3 Limitations

The first limitation of this study is clearly demonstrated by non-discussion of, for example, detailed post-innovation performance of the technology (start-up) enterprises. The post-innovation performance would have been critical when assessing the technology capability because it would indicate the enterprises' ability to retain and expand their market share over a reasonable period. In short, one of the important performance indicators of the technology capability must have been the ability of the enterprises to commercially sustain their business, that is, illustration of the nexus between technological opportunity, market need, responsive innovation and commercialisation.

Furthermore, the research population of the technology (start-up) enterprises in The Innovation Hub is not very representative of all technological industries. As a result, the non-representativity does not provide an opportunity to fairly compare the experiences of building technology capability from sector to sector. Inter-sectoral/enterprise differences exist and each sector/enterprise reacts to changing market conditions according to its rules and peculiar circumstances.

These limitations are compounded by the fact that in South Africa, only limited evaluative written work has been done in this area. If this is to be amended, extensive financial support and appropriate human resources would be required.

It is not the intention of this study to dwell on all the facets of competitive technology capability or regional and national economic development, nor to assess co-ordination, integration and management activities of The Innovation Hub in creating a fertile intersection for the building of technology capability. These issues on their own constitute distinct core studies demanding different analytical frameworks.

Although a well co-ordinated harmonious policy framework is integral to success in building technology capability, the intention of this research has neither been to assess the political leadership, administrative, analytical and co-ordination capacities inherent in any prudent policy performance management, nor to assess the relationship between legislative/policy and programme outcomes, but rather to simply acknowledge that "policy" is able to create conducive environments, and if well utilised, the desired "impact" is likely to be achieved.

1.5 Chapter Outline

This chapter demonstrated that high knowledge-intensive technologies are critical and strategic for economic growth and performance of nations. However, South Africa's endeavours to achieve this were challenged by socio-economic inequalities and a competitive global economy. It linked the macro-economic development policy with the concrete translation thereof into an implementation programme, The Innovation Hub. This is both a new concept for generating change in technology capability and a programme serving as the intersection between ideas and action, between research and development, and between innovation and entrepreneurship with the primary purpose of commercialization. It was demonstrated that the objective of The Innovation Hub is in the main to promote technology (start-up) enterprises so that they can effectively contribute to national economic development and growth, underscored by improvement of quality of life and wealth creation. Its strategic location in Gauteng enables it to access and interface with almost all the best social, economic, political, technical and innovative support networks in the country.

More significantly, an attempt was made to clarify the relevance, significance and objectives of "policy". The chapter highlighted the translation of policy into concrete

programmes as part of policy implementation. It then critically delineated the significance of programme outcomes in order to reflect their usefulness in "impact" and/or policy evaluation. By so doing, this chapter set the context for evaluation of policy on the programme effectiveness level as affirmed by the definition of "impact" above. The aim was to introduce and define the notion of "technology capability".

This introductory chapter provided a foundation to better understand the concept of "technology capability", as being continuously upgraded competitive capacity and ability to provide technologically based solutions and to support long-term sustainable development which gives an enterprise, industry or nation an economic and commercial edge over others.

Chapter 2 focuses on the dynamics and aspects of technology capability, and aims to identify and evaluate the positive changes made by The Innovation Hub (particularly the Maxum incubation) programme on technology (start-up) enterprises. In addition, chapter 2 develops an analytical framework that discusses the notion of "technology capability". This includes three factors affecting the rate and direction of technology capability building process. The chapter concludes by summarising the model useful for assessing technology capability.

In chapter 3, the methodology and approach used to assess technology capability is outlined. Based on the discussions in chapter 2, four types of performance indicators, that serve to complement the research methodology, are also outlined. The strengths and weaknesses of the method are discussed towards the end of the chapter.

Chapter 4 presents the findings in keeping with the approach, methodology and performance indicators presented in chapter 3, based on data/information solicited from the interviews, the relevant available literature, and the author's observations. Both the qualitative and statistical data/information are used to examine the validity of the findings.

The findings are critically interpreted in chapter 5, which also draws the main conclusions and discusses the implications thereof. Finally, recommendations including the possible avenues for future research are presented in chapter 6, based on the research findings, the author's interpretation of the findings and the conclusions made.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

For any systematic analysis to be comprehensive, there is a need to first establish a framework, either theoretical or practical, within which the analysis can take place. Similarly, for a better understanding of technology capability and the related building process, this chapter starts by tracing the basics of "technology" in an attempt to establish a framework for critical analysis. Such a framework is based on a plethora of concepts, definitions and characteristics drawn from a wide range of literature on the subject.

While recognising that there is no universally agreed definition or characteristics of technology capability; this chapter attempts to set out an analytical framework for the evaluation of the technology capability impact of The Innovation Hub. It makes the key distinctions between technology innovations and their bearing on technology capability, then critically examines the three factors crucial to driving technology capability – FDI, R & D and HCD. These will be discussed with the dual intention of establishing an analytical framework, and will set the scene for performance indicators against which The Innovation Hub's success can later be evaluated.

2.2 Understanding Technology and its Dynamics

2.2.1 Defining Technology for Understanding Technology Innovation

As the word "technology" underpins this study, it is imperative to define and understand its basics. In defining "technology", Adams (1997, p. 195) starts by making a distinction between "technology" and "new technology". On one level, he uses the same definition of "technology" given by the Little Oxford Dictionary (1980 edition) by referring to technology as "applied arts and sciences" (Adams, 1997, p. 195). Of great interest in this definition is, of course, the aspect of "application", which presupposes a formula or a process of actioning.

On another level, in his contrast of the conventional meaning of technology with "new technology"; Adams (1997) asserts that "new technology" is not just a formula, a process or a production line, but emphasises that "it is part of a complex web involving sophisticated operational management" (Adams, 1997).

It is worth isolating two dimensions in this definition. One is the "sophisticated" dimension which essentially modifies the operational management of a special type. This dimension is in essence similar to the conventional definition of technology but differs in terms of form and extent of operation. One could therefore be tempted to conclude that the "operation" in this regard requires application of knowledge of a special type i.e. unique value-adding knowledge.

The other dimension is the "complex web". It remains a fact that this dimension, just like the first one, is more about the environment of "application" of the value-adding knowledge. However, the "application" of the knowledge environment in this respect is "complex". Given this "application"-orientated definition (of great interest, especially for the last dimension) there is also the fact that "new technology" is not a system on its own but part of the system. This fact is attested to by Adams' assertion (1997) that it is a thing which upgrades and improves itself through links to the international market. The upgrading and improvement attributes of technology mean that the international market constitutes the systematic framework within which new technologies can be defined. Furthermore, they imply that "new technology" is continuously relative in keeping with the market changes and knowledge markets.

The market-determined definition of technology raises on one level the context of the respective capability and/or capabilities of technology in question. On the other hand, it also raises issues of technological innovations and their respective effect/s. With regard to the latter, the focus is more on the market competence and fitness of technology in comparison with other technologies. In terms of the former, the emphasis is more on the "upgrading and improvement attributes" previously mentioned.

It is critical for The Innovation Hub to take note of a strong linkage between the two. It is only through upgrading of technology (innovation) that there can be new technology capabilities that respond to market needs and determinants. The response to these market

needs and determinants in turn reflects the enterprises' technology capability differences. The intrinsic requirement for continuous upgrading of technology is therefore unique value-adding knowledge, expected to be acquired by the technologically successful (start-up) enterprises. In short, the "impact" on technology capability of the (start-up) enterprises should reflect a clear shift from low-end S & T applications to more sophisticated or improved S & T applications.

2.2.2 The Empirical Illustration of Technology Innovation

The previous section (2.2.1) illustrated the intricate relationship between technology and, closely linked to it, innovation; and conclusively interpreted such relationship as technology innovation. Following this brief overview, technology innovation in practice essentially explains the processes of successfully:

- *Turning a novel technical idea into a novel use*

  In 1985, the idea of an engineer who had gone blind in 1978, that blind people should have access to and use computers was technically novel. As a result, the effort of developing his first screen reader software, JAWS, represented a process of turning a novel technical idea into a product. Today, the product's ability to convert computer text to speech represents one of the successful novel uses which is the outcome of a novel technical idea to technologically address the visual impairment gap.

- *Turning an already developed technical idea into a novel use*

  In 1989, an entrepreneur specialising in optical character recognition (OCR) brought the benefits of his OCR technology to those who are sight-impaired by developing a software-based reading system, Open Book. When documents are scanned, the Open Book uses the computer's sound card to read documents aloud. In other words, OCR technology represents the already developed technical idea. However, this already developed technical idea became unique value-adding knowledge when it was adapted to and used in a novel (scanning and reading) environment. This illustrates the importance of knowledge in the market in response to market changes, namely, the need for blind people to have access to print data.

- *Turning a novel technical idea to a familiar use*

  An electrical engineer with an advanced degree in computer science developed the Braille 'n Speak, one of the world's first computer note-takers. The product had Braille key input and speech or data output. This product manifested a successful process of turning a novel technical idea into a useful product because it included functions like quietly taking notes, keeping address books and updating personal calendars, to mention but some examples. However, due to their familiar Braille key input, refreshable Braille display and speech or data output; the recently upgraded (combo) note-takers like PACMate represent technically novel products within familiar uses.

- *Turning an established technical idea to an established use where, previously, the attempt resulted in commercial failure*

  Although it has not been a commercial failure; JAWS for Windows is the world's best-selling screen-reading software, exceeding 100 000 users worldwide. In part, its significant sales growth is due to its contribution in enabling blind or sight-impaired people to achieve the same or higher productivity in computer-based jobs as sighted people. Equally, the company's marketing capability coupled with the inevitable need for socio-economic integration of and participation by people with impairments in the mainstream society serve as an impetus to sale growth.

These examples demonstrate the continuously upgraded capacity and ability to provide technologically based solutions and to support long-term sustainable development. In order to examine the impact of The Innovation Hub on the technology capability of the technology (start-up) enterprises; there must first be identifiable evidence of some acquired unique value-adding knowledge in keeping with the market changes and knowledge markets, which demonstrate novelty in either idea or use.

2.2.3 Forms of Technology Innovation and their Bearing on Technology Capability

The empirical illustration of the technology innovation outlined above (2.2.2) necessitates a need to differentiate the forms and attributes of technology innovation. Scholars like Miles (1994) as a result distinguish technological revolutions from incremental and radical

innovations of technology. Incremental innovations are explained as continuous "small modifications in products or processes, with at most minor changes in training and work organisation" (Miles, 1994). The practical examples of incremental innovations include the improvement/upgrading of the PACMate from BX and QX series to 3.0. The purpose of the upgrading was to enable the users of these products to control a desktop PC remotely via ActiveSync, when used in conjunction with the new JAWS 6.20. This incremental innovation was meant to provide a technical solution to the inability to control the desktop computer from the PACMate over a wireless connection.

Radical innovations, on the contrary, involve "more substantial change(s) in production processes and organisational arrangements, and/or new products which establish new markets or displace familiar products from established markets" (Miles, 1994). The introduction of the first (combo) note-takers with synthesizer and Braille display itself – when compared with the traditional manual Braille machines –could also be regarded as a practical example of radical innovation because:

- A more advanced unique value-adding knowledge was required in the production process;
- The note-takers as new products displaced the Braille manual machines; and
- Most importantly, the note-takers, unlike their predecessors, included word processor, planner, scientific calculator and file manager functions.

Another significant form of technological innovation is technological revolution or techno-economic paradigm. Although techno-economic paradigm (TEP) entails basic elements of incremental and radical innovation, it is, according to Miles (1994), more profoundly based on "scientific discoveries, which yield new basic knowledge about fundamental processes. This new knowledge, and the techniques associated with it, allow for changes to be made in extremely wide ranges of products and processes since the knowledge is employed to develop fundamentally new and far-reaching inventions – allowing new "heartland technologies"" (Miles, 1994). The discovery of opto-electronic technology is a classical example of TEP because it led to the introduction of liquid crystal display (LCD) products and OCR technology, which was subsequently adapted to Open Book products, as well as many other related but previously obscure products.

Miles (1994) refers to Perez (1983, p. 361) in his outline of some of the basic conditions for innovations being revolutionary technologies:

- Clearly perceived low – and descending – relative cost;
- Unlimited supply for all practical purposes;
- Potential all-pervasiveness; and
- Capacity to reduce the costs of capital, labour and product as well as to change them qualitatively.

A number of implications can be drawn from the different forms of technology innovation that are taken into consideration when assessing the impact made by the Maxum incubation programme. The first is that TEP by definition has "pervasive effects":

- On products and processes;
- On working practices and inter-company relationships; and
- On the centres of economic power.

Simply put, it has effects throughout the economy (Walsh, et al. 1998; Miles, 1994). "Pervasive effects" in this context should be understood not only as leading to the emergence of a new range of products, services, systems and industries in its own right. It should also be understood as affecting directly or indirectly almost every other branch of the economy (Walsh, et al, 1998). In other words, TEP leads to a quantum leap in potential productivity for all or most of the economy, and the opening up of an unusually wide range of investment and profit opportunities (Walsh, et al, 1998). One of the key criteria is whether the (start-up) enterprises have experienced any of the three "pervasive effects" as outlined above as a result of their involvement in the Maxum incubation programme.

The second implication is that the three forms of technology innovation differ mainly in terms of the extent of innovation and its impact. The challenge for The Innovation Hub in this regard is the extent to which it manages to facilitate innovations in any of the three forms of technology innovations. The TEP presupposes the existence of "a core technological framework which is shared by the entire community of technological and economic factors as the basis upon which one looks for improvement in process efficiency

and product performance" (Miles, 1994). Needless to say, every economist would aspire to making a breakthrough in TEP, although this may be difficult to achieve.

Miyazaki (1995, p. 28) critiques the traditional classification of technology innovations, pointing out that "accumulated incremental change over a long period can be difficult to distinguish from a radical change. Major technical changes often grow directly out of experience in the use of earlier vintages of technology, and build cumulatively upon them …. [In other words], a period of trial, error, learning and associated incremental change is necessary before a major new technology begins to reach its potential." Today, for example, with regard to major improvement in product performance and efficiency; the recently produced note-takers such as the BrailleNotes and PACMates are indeed representing radical innovations that have been cumulatively developed through trial, learning and associated incremental changes. The essence of these implications for the The Innovation Hub is that technology capability of the (start-up) enterprises should be characterised by evident development of new products/services, emergence of new opportunities for their products/services and the recognition and seizure of the opportunities for, mainly, commercial gain.

In light of the critique of the traditional classification of technology innovation and for a better critical analysis and in-depth comprehension of technology capability-building – especially within the context of The Innovation Hub – a number of issues should be examined. The first is to differentiate product innovation from process innovation. While the former involves "the introduction of a new good … or a new quality of a good" (such as the JAWS 7.0 as the most advanced screen-reading software), the latter involves the introduction of a new method of production … "(or) a new way of handling a commodity commercially" such as organisational form and skills required to design, develop and produce upgraded versions of JAWS (Edquist, et al, 1998, p. 129). Whereas product innovations are primarily, but not exclusively, the most important engine of structural economic change; process innovations (both technological and organisational) normally have the net effect of efficiency and effectiveness. Within the context of the impact made by The Innovation Hub, the indicators for evaluation of technology progress and/or capability include the improved net effect of efficiency and effectiveness of the (start-up) enterprises.

The other innovation dimension worth emphasising is that of technological process innovations. These are units of real capital (material goods) that have been improved through technical change and that lead to productivity growth in their use. They can appear in two "incarnations" in the economic system, where an industrial robot is a product innovation when produced and a process technology when used (Edquist, et al. 1998, p. 131). In some cases the production of new products requires the modification of process technologies. In other cases, product innovations do not require new process technologies. Another dimension closely linked to product-process innovation relationship is "when the same – or similar – product is produced with radically different process technologies. An example is human growth hormone, which was previously extracted from human pituitary glands and is now produced through genetically engineered cells" (Edquist, et al. 1998, p.131).

Finally, it is worth noting that organisational process innovations are most often inherent features of technology capability. In pursuit of (organisational) productivity, both work reorganisation and new organisational form are introduced. All these represent the intangibles of technology capability. In other words, the nature of some product innovations is most often the leading propensity to innovatively reorganise work process at the company level. One practical example of this could be the financial take-over of the three companies specialising in different assistive devices for the blind and the subsequent formation of the new Freedom Scientific, or business merger of PulseData and VisuAide that resulted in Humanware. Within the context of The Innovation Hub, the impact made on technology (start-up) enterprises should also be noticeable through organisational and work innovations as demonstrated by acquired organisational productivity, efficiency and/or effectiveness.

2.2.4 The Implications for the Maxum Incubation Programme

The achievement of technology innovation, diffusion and capability are most often dependent on social networks like government awareness and promotion campaigns. For example, the demonstration of opportunities for particular products can reinforce innovative practices. The importance associated with this social promotional collaboration is premised on the fact that all technologies are created by human beings for the satisfaction of human needs and thus socially shaped. For example, the development and

continuous upgrading of JAWS increased employment and educational opportunities for the blind while helping employers meet requirements established by the Americans with Disabilities Act (ADA). The continuous upgrading of the product is also informed by customer/user feedback. In articulating the social dimension of technology capability, Miles (1994) cites Rene Kemp in his argument that the successful building of technology capability involves "a combination of interrelated product and process, technical, organisational and managerial innovations". These facets of technology progress and/or capability are dependent on the ability of government policies to create the environment within which technology innovations, diffusion and capability can be enhanced. Of great significance within the context of the impact made by The Innovation Hub is how the (start-up) enterprises experience the policies intended to create the environment within which technology innovations, diffusion and capability can be enhanced, and the role played by The Innovation Hub in attaining this social dimension of technology capability.

The social dimension requires careful management. Technology capability building, especially technological revolution, is a time of both great excitement and great uncertainty. There is much hyperbole or exaggeration – sometimes justified. This study therefore seeks to assess the impact made by The Innovation Hub on the technology capability of the (start-up) enterprises.

The abovementioned introductory analytical framework has emphasised certain critical aspects which are necessary for evaluation of the "impact" made by The Innovation Hub on technology capability of the (start-up) enterprises. The following are some of the implicit aspects:

- Firstly, as "application of science" underscores technology, The Innovation Hub must clearly generate the unique value-adding and/or necessary S & T knowledge enabling the (start-up) enterprises to commercially provide technological solutions.
- Secondly, the (start-up) enterprises must demonstrate the capacity not only to recognise the market needs and changes as the emergence of new opportunities but, most significantly, utilize and exploit them commercially.
- Thirdly, the ability to recognise, seize and exploit market opportunities should be supported by the concomitant ability to responsively develop technically novel ideas and/or use. The responsive development of novelties should generally be manifested

through product/service innovations, which are incremental, radical and/or revolutionary, though the three often overlap.

- Fourthly, improvements on organisational productivity, efficiency and effectiveness of the (start-up) enterprises should be noticeable if indeed "impact" on their technology capability has been made.

In the following section, these aspects are further evaluated within the context of the factors driving technological development, which include, but are not limited to, the desire for profit; the need to exercise and maintain power; and the impetus of the research establishment to know what can be known (Adams, 1997, p. 197).

2.3 Perspectives on the Technology Capability Factors

There are a number of technology capability factors, which are integral to the generation of S & T knowledge and thus ultimately the building of technology capability. However, this study is confined to three factors, namely, FDI, R & D and HCD. This selective focus does not posit the hierarchical importance or the exhaustive nature of these factors.

For policy-makers, the role of government in stimulating these factors constitutes the key debate. The concern of the policy-makers is to come up with appropriate policies to influence and stimulate an enabling environment in which innovation and technology diffusion can take place. The debate on the government's role is characterised by, and exhibited through, a lack of consensus on the appropriate systemic manner in which to manage these factors, as their effectiveness is experienced differently by different countries. Most often, these factors manifest a symbiotic relationship, with each feeding on and in turn being stimulated by the other in the process of building technology capability.

To this end, this section discusses the theoretical framework used in this study within the context of the factors which affect the rate and direction of technology capability-building. The broad theoretical perspectives on the subject under discussion are substantiated with their respective practical international examples. For a coherent understanding of the impact made by The Innovation Hub on the technology capability of the (start-up) enterprises, the broad (macro) experiences are then interpreted and translated into the

specific (micro) policy implications for the (start-up) enterprises in The Innovation Hub. The implications of the author's interpretation are contextualised within the questions raised in, and/or research propositions made under, the Problem Statement (1.4.1). In particular, this seeks to explain the extent to which existing policies have created the environment within which technology innovations, diffusion and capability were in turn enhanced. It also highlights the importance of technology capability factors in feeding on, and in turn being stimulated by, the others in this process.

2.3.1 The Role of FDI in Technology Capability

- *The Context for Policy Debate*

The interpretation of the government's role of stimulating technological process through promotion of investment, is in this research largely confined to FDIs, mostly, in the form of trans-national corporations (TNCs). However, this selective focus should not be interpreted to mean that domestic investments do not play a significant role in the process of building technology capability. The predominant focus on this exogenous factor in building technology capability seeks to critically reflect on the "effectiveness" of FDIs rather than to concentrate on the details of image building and investment generation activities and/or services as detailed by, inter alia, Bagus (1999).

In order to examine the effectiveness of FDIs and in particular TNCs, it is necessary to consider the important dualistic point made by Loveridge (2002). In his debate on the role of TNCs, he posits that, on one hand, the significance of the TNCs in creating the necessary scientific and technological knowledge is derived from its unique internal capabilities, combined with its ability to exploit the relative advantages contained in the local context of its overseas investment (i.e. source of monopolistic advantage). On the other hand, he notes that the regulation of access to local resources by the host nation state is an attempt to gain economic advantage from the location of the TNC in its territory. The situation therefore is either:

- A variable-sum game, where there is a mutual benefit from FDI; or
- A zero-sum game, where there is one side benefiting or where one is able to coerce and to exploit the services provided by the other.

This could most likely represent an ongoing relationship of contest and collaboration. Hence, countries make and support clearly defined and targeted policy decisions responding to their specific needs, opportunities, challenges and/or constraints of the given time. South Africa's recognition of this delicate issue is illustrated by the question posed in chapter 2 of the WPST (1996): "How can we participate globally without merely throwing open our markets to foreign products, thus increasing our dependency on the developed world?"

- *The Policy Debates on FDIs*

The policy debate for and against the role played by, and the effectiveness/impact of, FDIs in the process of building technology capability has been described. The FDI proponents hold that the more rapid growth of FDIs reflects technology payments, and thus in the final analysis FDI's effectiveness in building technology capability (Chang, 1998 p. 98). In other words, the TNCs' internal capabilities contribute towards S & T knowledge of the host company, industry or state, if well-exploited.

Opponents of FDI, however, maintain that most FDIs occur amongst the developed, as opposed to developing, countries and question the efficacy of technology investment through TNCs in building technology capability. For example, Loveridge's (2002) findings indicate that the interest of the TNCs in the ASEAN region stemmed from a realisation that the European market for their products was both limited and crowded. These findings could be extrapolated as being indicative of the exploitative nature of the FDIs or the TNCs' domination of the international trade. Within the context of The Innovation Hub, the two conflicting views on the impact of international investment presuppose that the adopted policies could either enhance or impede competitiveness of the (start-up) enterprises.

Furthermore, the FDI proponents hold that the rapidly increasing "trans-national" nature of the FDIs testifies the "stateless", but mainly economic/commercial, nature of the FDIs. This is demonstrated by relocation of core activities such as R & D out of the home countries, referred to as the "complex integration" (Chang, 1998 p. 99). The FDI opponents maintain that the TNCs remain international firms with a strong base, in assets and production activities, in their "home" countries (Chang, 1998 pp. 100-101). The

evidence in support of the concern raised by the FDI opponents in this respect has been elaborated by Dhungana (2003, p. 12) in relation to Malaysia:

> It is also true that our industrialisation process contains serious impediments, which include heavy reliance on foreign technology and innovation, reliance on imports of machinery, equipment and intermediate inputs and even labor. If this scenario is permitted to persist, Malaysia will continue to be a mere assembling country for multinational corporations (MNE).

The exploitative nature of the FDIs should not be taken to the extreme, since empirical evidence points also to the converse. For example, Malaysia is the third largest producer and the largest exporter of semi-conductors as a result of the role played by FDIs. In 2000, it produced 16.4 billion units worth of semi-conductors, an increase of 64.7% over 1999. The increase in the production of Elec & Eltek (E & E) parts and its components was due to the increase in worldwide demand for computers and telecommunications equipment, especially in the Asia Pacific region. Companies producing semi-conductors in Malaysia include Advanced Micro Systems, Harris, Hitachi, Intel, Motorola, National Semiconductor, Hewlett Packard, NEC, Philips, SGS-Thomson and Texas Instruments.

These diverse international experiences help in assessing the policy direction of The Innovation Hub regarding FDIs. For example, on a policy (programme) implementation level, the impact on technology capability should feature the acquired S & T knowledge generated through the internal capabilities of the TNCs. In other words, what are the policy aspects put in place by The Innovation Hub to ensure that the (start-up) enterprises mutually benefit from, but are not exploited by, the FDIs?

On another level, FDI proponents hold that, depending on the environment of the FDI recipient country, open trade and liberal FDI policies can provide access to needed capital, advanced technologies, sophisticated managerial practices, and distribution networks in the export markets (Chang, 1998 p. 99). This view is in keeping with the regulated access to local resources in attempting to gain economic advantage from the TNC's location in the recipient company, industry or nation. The Malaysian semi-conductor and E & E performance could potentially serve as supporting practical evidence.

The validity of FDI in certain instances might also be questionable because policies towards FDI are bound to be selective and require constant review. To cite a complex situation, Malaysia has opted to be a fast follower and concentrated on importation of expertise through the FDIs. In the process, Malaysia could have paid less attention to research and patenting than it did to effective technology transfer and the broadening of scientific literacy in the general population. While this strategy paid evident dividends in the short term, it has also been unable to maintain the high growth rates seen previously (Dhungana, 2003, p. 12).

The experiences of building technology capability in South Korea and Taiwan point to an unusual strategy. Their success in the high technology sector emanated not from prior competencies, but from technological licensing. This suggests that one can acquire new technology capability from others, but only when one is lagging behind, and only when the basis of competition has shifted from technological leadership to price-based competition (Miyazaki, 1995, p. 30). The logical deduction is that one of The Innovation Hub's performance indicators must be a consciously adopted strategy of building technology capability.

- *Lessons for the Innovation Hub*

The theoretical positions regarding the efficacy of the FDIs demonstrate the challenges inherent in managing them. In expanding on the complex nature of this debate, in response to the FDI chasm highlighted above, Dhungana (2003. p.12) advises that unlike other flows, the FDI is a "package" which contains capital along with management, technology and skill, and should take precedence over others. Experience in developing countries suggests that purchasing technology through licences and negotiating management agreements are less efficient, in terms of gains in productivity, than "unbundling" the FDI package. Logically, this advice calls for continuous application of the concomitant capacities underlying policy management in The Innovation Hub, namely:

- To accurately analyse trends in the environment, policy performance (management) and review;
- To make and support clearly targeted policy decisions responding to the specific needs, opportunities, challenges or constraints; and
- To translate these into policy programmes/projects and allocate the required resources accordingly.

At an aggregated and also management level, the FDIs, particularly in the form of equity investments involving industrial relocation and complementation, can add to the capital stock of the country. This increase in the supply of capital enables the recipient country to achieve faster economic growth and bring about rapid structural change. As investment in new plants, equipment, transport and other forms of fixed capital take hold, the recipient country's productivity goes up, spurring the development of a competitive industrial sector. The FDIs can also replenish their existing industrial capital stock and contribute to releasing domestic resources for investment in physical and social infrastructure like schools, transport and communication.

The best scientific formula for building and managing technology capability starts with a clear appreciation of one's technological situation. The NRDS appreciates that in many areas where South Africa is presently competitive, there is little capacity for local innovation and the country depends on imported expertise and skill. It further notes that this is not problematic in the short term. However, countries that make strategic innovation investments will inevitably attract new FDI and will eventually secure or supplant the current productive capacity (NRDS, 2002, p.32). From a policy performance management point of view, the major policy determinants regarding the importance of the FDIs are:

- A particular imported expertise to be acquired;
- A particularly necessary capital to be accessed; and
- International distribution networks to be accessed.

In short, success in this regard is dependent on the ability to meet the c riteria that may possibly attract FDI. Some of the criteria set out by Loveridge (2002), which could be crucial in assessing the "impact" made by The Innovation Hub, are:

- Possession of low-cost labour services;
- Possession of scarce natural resources;
- The presence of scarce skills; and
- Expanding domestic consumer markets.

2.3.2 The Role of R & D in Technology Capability

- *The Rationale for R & D*

The impetus to know what can be known is another critical contributing factor to S & T knowledge generation and technology capability building. The research impetus to generate S & T knowledge and build technology capability is in this study confined to R & D. The author suggests that the appropriate model for R & D and its significance largely depend upon the role played by government through the policy environment. The appropriateness of the model is generally identified through satisfactory answers to the following questions:

- How can the research base be maintained and developed;
- Who should be involved in the research activities and when;
- How should R & D be conducted; and
- Where should R & D take place?

Answers to these questions are in the main on an operational level and not on the outcome level. However, the locus of the analytical framework in this respect dwells more on theories related to the effectiveness or the outcomes of the R & D and the specific policy implications thereof within the context of The Innovation Hub.

As already alluded to, R & D is one of the activities that increase scientific knowledge, which in turn can result in technological expertise. Therefore, R & D can be construed as subordinate to innovation, in that it is one activity which contributes directly to scientific and technological change. The implication is that in the study of innovation one cannot be content solely with the issues of R & D. In fact, the identification of other activities, their relationship and measurement become an integral part of innovation study. Simply put, R & D is nonetheless one part of the knowledge infrastructure, in terms of which knowledge can be expressed and stimulated as it helps stay abreast of technological changes and relevant knowledge.

This view is in sharp contrast with the linear model, which has until recently been used largely by policymakers to explain the dynamics of building technology capability. This model advocates that (technology) innovation takes place in a linear pattern. It starts with research, then invention, moves on to innovation, and finally diffusion of new techniques.

In other words, R & D is a pervasive aspect of technology innovation, and in the final analysis capability. Based on different approaches and valuing of the R & D, the importance associated with technology capability through The Innovation Hub would be evident in the degree of significance linked with it.

As a result of the overwhelming criticisms against the linear model in explaining scientific and technological change, other forms of creating scientific and technological knowledge are increasingly dominating the analytical modes of explaining technology capability building. Purchase of knowledge and embedded knowledge are some of the examples of other forms of increasing scientific knowledge for technology capability building. For example, much of the ASEAN NICs' industrialisation was initially predicated not on local innovation, but on accessing technology from abroad and adapting and assimilating it so as to secure major productivity or efficiency gains in general. It is therefore important to look into different forms of R & D.

- *Generic Forms of R & D*

Briefly, there are different forms and models of R & D with diverse possibilities for participation. In general terms, one form of R & D is externalisation or outsourcing of R & D, and the other is internalisation of R & D. The choice between the two differs from one company, industry or country to another, and is always informed by given peculiarities.

In essence, the externalisation of R & D refers to the use of firms and organisations specialising in contract research and technology (CRT) (Howells, 1997). R & D in this model is posited as corporate function and activity where internal R & D process now has "an important technological scanning role". CRT has also played an important role in the creation and development of the "research market", in terms of the commercial purchasing and trading of R & D and technology. However, in the context of The Innovation Hub, this model would be limiting the generation of S & T knowledge, which is critical in sustaining technology capability.

Another explanatory position for externalisation of R & D is the transaction-cost model. The transaction-cost model represents "a shift from an in-house vertical and hierarchical provision towards a more market mediated approach". Furthermore, it is related to notions of "strategic assets" and "core competencies" of the firm. Simply put, the firm should

concentrate on what it is best at. As funding of innovation is emphasised by nearly all policy documents, The Innovation Hub should therefore substantially fund R & D activities, as the start-ups are in the main financially vulnerable.

In view of the dynamics of the transaction-cost model sketched in the supra-paragraph, the push-and-pull model is by extension another form of R & D. The push-and-pull model is in a way a modification of the transaction-cost model. On the push factor side, the enterprises are in the main worried by the increasing complexity of the research process and the cost and risks associated with conducting R & D internally. In short, research may become less attractive without partners to share the costs involved.

On the pull side of this model, the explanation is in the main centred on "the relative attractiveness of external sources of expertise over internal firm resources. From the internal firm perspective, the desire is to have the external expertise

- Enhance the scope and testing of in-house scientific and technical activities;
- Serve as a general scanning mechanism of technological opportunities; and
- Serve as a means to network with other organisations.

Thus, the interaction of the internal and external expertise of the organisation, by implication, represents an "invisible college", straddling the line between internal and external identities of enterprises.

In the international context, similar strategic alliances and co-operation sometimes take the complex form of, or are regarded as, joint ventures. However, Loveridge (2002) cautions against joint R & D and product development between TNC and locally-owned companies. They often obscure national origins and/or indigenous identities of the host country. On the positive side, especially when the collaboration is horizontal, joint venture can contribute to co-ordination of domestic markets, and to promotion of new knowledge and enterprise, and thus form "an essential element in the emergence of national innovation systems" (Loveridge, 2002).

At face value, the model adopted by The Innovation Hub in this regard appears to straddle the line between the models described above. For example, the CSIR is mandated to specialise in research; whereas the (start-up) enterprises are neophytes in the field of R &

D. However, the (start-up) enterprises do not merely perform a technological scanning role. They actively participate in the R & D activities, as the objective is to impart entrepreneurial knowledge. The success of this strategy might work if there is preferential allocation of government contracts, as was the case in Malaysia and more recently in South Africa through the BEE approach.

- *Empirical Relationship between R & D and FDI*

Under critical scrutiny, similar patterns to those of FDI discussed above are evident when looking at international R & D and/or innovative activities aimed at technology transfer. The example of Malaysia is clearly demonstrated by Abdullah (2002); more than 90% of the TNCs spent an average of 1% or less of their turnover on R & D. Only two in a sample of 27 TNCs spent between 2% and 5% of turnover on R & D. For the Malaysia/foreign-owned firms, four companies out of 24 spent between 3% and 5% of turnover on R & D. The bulk of these R & D efforts of TNCs take place in the parent companies where extensive R & D facilities have already been established. The NEC, for instance, in its 1990/91 financial year, spent US $5 billion, or 17% of total group sales on R & D. Others, like Fujitsu, invested 11% of turnover on R & D while Hitachi, Toshiba and Sony spent between 5.7% and 6.3%. Only one Malaysian-owned company and one joint venture company in the sample could match such massive investments in R & D undertaken in Malaysia.

Less than half (44%) of TNCs operating in Malaysia have their own R & D department/units. Basically, these departments/units undertake application research, that is, the adaptation of the developed concept into products or services for specific market niches. Therefore, the control of what type of R & D is done and where it is located is still very much a centralised decision and viewed from the perspective of the long-term goals of the TNC as a whole, rather than those of its individual affiliates. A logical deduction to be drawn from this revealing illustration is that higher R & D-intensive activities usually take place in home TNCs and, if any, less knowledge-intensive R & D activities take place in host (less developed) nations.

With regard to R & D activities among the Malaysia/foreign-owned companies, the majority of the joint venture companies have R & D capabilities, albeit on a very small scale, within their companies with strong mutual involvement and support from the TNCs'

homes. The foreign counterparts were relied upon to provide the technological expertise and to solve technical problems. There was also some degree of formal research for product development through in-house research or joint or contract research. Smaller Malaysian-owned firms rely primarily on imports of foreign technology through vendors and suppliers of machinery and equipment.

- *Lessons for The Innovation Hub*

In the final analysis, the effectiveness of any form of R & D depends on the set performance indicators. One of the critical indicators against which to assess the impact made by The Innovation Hub should be the extent to which it managed to meaningfully involve the (start-up) enterprises in the R & D activities aimed at:

- Adapting international best practice to local conditions in response to local market realities; and
- More significantly, adapting the developed concepts into products and/or commercialising the scientific or academic findings.

The monitoring and evaluation of R & D performance and effectiveness is also based on the patentability of product and process innovations and the number of patented innovations. For example, inventors from South Africa secured 57 patents in the US in the period 1985-1999, making it one of the top innovative countries in the developing world. However, on a deep value level, an examination of the patenting behaviour of inventors from South Africa shows that, of the 284 patents that were granted in the period 1995-1999, more than 75% were awarded to individuals and the rest to domestic and foreign firms. Domestic firms include two governmental agencies, the Atomic Energy Corporation with ten patents and the CSIR with nine patents. The only foreign company that has secured patents is British Technology Group (BTG). As a result of this, the first South African innovation survey concluded that, because most firms are engaged in "merely" incremental as opposed to radical innovation for which they make use of foreign technology, the country was in essence a technological colony of its European masters (Oerlemans et al., 2003).

These aspects of different models of R & D together with the diverse practical examples suggest that, as maintained by Sung et. al., 2003, p. 451):

- There is not just one process of innovation;
- Key research does not simply occur at the initiator stage or R & D;
- Rather than just being used as the starting point of the innovation process, research results can be used, in one form or another, at all stages of innovation; and
- The relationship between basic research and commercialisation is too complex to be understood as a linear relationship.

For example, users of the product and/or process innovations and their ideas about them can lead to changes in the innovations, and thus be another starting point for subsequent innovations.

In light of these perspectives on the role of R & D, there are generally two types of learning. Firstly, at the basic end of R & D, "the learning process involves the acquisition of knowledge concerning the laws of nature". Secondly, at the development end, "learning involves searching for the optimum design of a product, or "blueprinting" activity" (Miyazaki, 1995, p. 32). For The Innovation Hub, the key question is how The Hub managed and stimulated the flow of knowledge and technology between the university, R & D institutions, enterprises and markets.

In short, the success of R & D is inseparably linked to human capital development (HCD). The major functions of the combined human capital/resources and R & D are to drive improvement and innovation in the economy (as well as being involved in smart adoption of imported expertise) with the ultimate objective of building own technology capability. Simply put, the best strategy for the technology (start-up) companies to build their own technology capability is to involve themselves in joint R & D and/or innovative activity agreements that can reasonably assure them of long-term quality expertise and information, which includes the capacity to absorb, accumulate and exploit technical and/or professional knowledge.

2.3.3 The Role of Human Capital Development in Technology Capability

- *The Importance of HCD*

The discussions on the efficacy of FDIs and R & D have already revealed the crucial role of knowledge infrastructure in technology capability. According to WPST (1996), one of the things a society must do well in order to survive and prosper is to "ensure that its members develop and continually update the knowledge, competencies, abilities and skills that are required to produce innovative products and services." Similarly, on the policy implementation level, The Innovation Hub concisely captured the importance of education by asserting that "science and technology can help create a better life but the greater more lasting opportunities lie in the realm of education and skills development by equipping young people with hands-on know-how and practical experience" (Annual Report, 2002/03, p. 21). This suggests that central to The Innovation Hub's strategy is to critically evaluate inward investment against the contribution and change it makes to the development of entrepreneurial skills and capabilities within indigenously grown (start-up) enterprises, which are central to the national economic development as well as appropriative learning. To summarize this viewpoint, technological trajectories result in part from the quality of the knowledge infrastructure and the degree and the rate of absorption of both the existing stock of knowledge and additions to it.

- *Theoretical Frameworks on HCD*

Scholars acknowledge the importance of skills development but disagree on the role government can, or should, play in this regard. There are traditionally two schools of thought on this subject. One school sees the market as the principal mechanism for skill formation. The role of government, if any, in this respect is minimal and only corrective of the market. In other words, the market on its own is responsible for the co-ordination of the demand and supply of skills, enhancement of the skills, and rewarding for acquisition of skills.

The other school of thought sees the "government action as an integral component of the labour market". In this respect, the government conceivably helps:

- To structure the operation of the market;
- To shift the basic equilibrium within which the market operates; and/or

- To change the incentive structure for the acquisition of appropriate skills.

In this regard, policy management plays a critical role in creating the necessary fiscal and incentive environment. The Innovation Hub appears to lean more towards this non-free market mechanism.

One of the drawbacks of the free market mechanism is "the imbalance (between) supply (and) demand (of) qualifications". Either the former outstrips the latter; or vice versa, as is the case with regard to highly valued technical skills in South Africa. The other drawback, inherently related to the former, is lack of deliberate encouragement for the acquisition of certain ostensibly valued types of skills (Ashton & Sung). To illustrate the nature of this embedded challenge in South Africa, WPST and NRDS are currently promoting the study of SET because of the significant shortage of skills in these disciplines.

To cite some international experiences, large-scale investment in human capital formation, particularly technical skills, has been a feature of all the Asian NICs, with Singapore being a particularly strong example. Apart from education and training, this has had many dimensions including attracting and accessing the skilled "diaspora" abroad. Where the requisite skills have not been locally available, concerted efforts have been made to attract foreign workers. For example, in Korea, foreign engineers were exempt from paying income tax.

The government co-ordination mechanism is not necessarily adequate to ensure that "changes in the demand for skills can be anticipated by changes in supply so as to minimise any delays in the adjustment process" thus far. One of its problems is picking winners, such as the type of industries to be developed especially when at the leading edge of world markets (Ashton & Sung). For example, the relative failure of Penang (Malaysian government-driven programme) to develop much beyond a low-value contribution to a global supply chain was partly attributed to its inability to develop a critical mass of highly skilled engineers and scientists (Loveridge, 2002). If strictly applied, the other drawback could be restriction of authority of educational institutions as government would decide what is available in terms of form, content and delivery of education (Ashton & Sung).

- *Dynamics of HCD in Practice*

HCD becomes particularly challenging when there are equity and redress issues. Experience in countries like Malaysia in the case of Bumiputera has shown that the greater involvement of people from previously excluded sectors of the community cannot be left to chance or to market forces. South Africa is not immune to this practice especially in view of its sharp socio-economic inequalities along race and gender lines. To this end, special programmes for the promotion of, inter alia, women in science, are already under way (NRDS, 2002, p. 30). Hence the first phase of the incubation programme focuses largely on the previously disadvantaged, and at an "impact" level, there should be at least a sizeable number of enterprises with technology capability run by previously disadvantaged persons.

The government's integral role in technology capability building, particularly in production and retention of highly valued skills, is crucial and influenced by global factors. In South Africa as in other parts of the world, recent studies show high attrition rates. Approximately 11% of researchers resign from government laboratories each year, while approximately 15% of researchers resign from universities each year. Of those who leave employment, some 5% of the government laboratory scientists and about 22% of the academics emigrate (NRDS, 2002, p. 44).

Both the FDIs and R & D activities are the other institutional forms of learning that help stay abreast of technological changes and decide on the most relevant knowledge to absorb and adapt. They are therefore not only – and often not even primarily – about generating new information in isolation. Ideas for innovation can come from many sources and any stage of research, development, production and marketing. Therefore, in the context of The Innovation Hub as the platform for the intersection between ideas and action, between research and development, between innovation and entrepreneurship, any knowledge infrastructure should appreciate, accommodate, facilitate and promote learning across the constituent elements of innovation system as all constituents aim at doing things better and differently.

The basic theoretical framework sketched above calls for a critical distinction between, and balancing of, the different forms of inter-firm technology partnering that The Innovation Hub encourages. One such important form is constructive technology alliance, which

ideally refers to those inter-firm agreements for which joint R & D and/or other innovative activities are part of the agreement and which can reasonably be assumed to affect the long-term product market positioning of at least technologically developing start-ups. This is underscored by three dimensions, namely, the (start-up) enterprises' successful ability of mastering:

- The nature and relative channels of technique-centred interaction;
- The characteristics of the main actors and the demand and supply they represent on the knowledge market; and
- The framework conditions, replete with incentive structures, that provide the setting for the knowledge market.

In sum, technology capability including the inherent entrepreneurship aspect is the ability to make effective use of technological knowledge, especially the proficiency of its use in investment, innovation and production (Miyazaki, 1995, p. 20). This is attested by the WPST (1996) view that "innovation is an encompassing notion that is based on the continuous production of new knowledge and its creative applications in a number of spheres. … the promotion of research, both applied and basic, in the natural sciences … is crucial to innovation and hence to … economic development." All these aspects need to be looked into based on the competitive reality of keeping pace with and perhaps occasionally overtaking the pack of competitors, while the competitors themselves are also developing strategies which will give them flexibility to move into a controlling position at various stages of the race.

2.4 Critical Observations for Analytical Framework of The Innovation Hub

The previous section has in the main concentrated on the broad literature related to technology capability building, and has assisted in laying a foundation for this section, which now seeks to re-align the literature within the context of The Innovation Hub. The aim is on one hand to move from the general to the specific, and on the other to explain the variables crucial in evaluating "impact" on a meso or programme level.

Firstly, the literature has revealed that the technological trajectories of nations, industries or enterprises depend on a range of factors. Key amongst them is knowledge and more particularly its effectiveness when used or, at the end, technology capability. In the same

vein, the (start-up) enterprises' technological trajectory should also be assumed to depend on knowledge. Of great interest in this respect is the identification of the most required and acquired knowledge that successful technology (start-up) enterprises require from The Innovation Hub.

Alternatively, some of the (start-up) enterprises could have managed to secure international deals as a result of their own attractive knowledge. One supporting theoretical example of this perspective, the "agglomeration" thesis, argues that technological activities in general are frequently drawn toward countries with revealed relevant technological advantages or technological potential. This is confirmed by the technological diversity thesis, which holds that innovations tend to embody or draw on a wider range of constituent technologies and knowledge bases already in existence or imminent. Therefore, the impact made by The Innovation Hub could possibly have been due to exposure of the technology enterprises to international technology business rather than knowledge generation.

Secondly, in light of the definition of technology innovation and capability above, introduction of the (new) products and/or services into the market is one of the critical indicators of technology capability. Therefore, in order to better ascertain the policy impact on the technology capability of the (start-up) enterprises, the enterprises should reflect at least one of the three attributes outlined by Miyazaki (1995, p. 15):

- Efficiency and effectiveness, measured by the characteristics of their products and production methods;
- Fitness, measured by their ability to expand production and marketing capacity; and
- Creativity, referring to the ability to transform their underlying product and process technology.

For better comprehension, these broad categories can be distinctly unbundled as follows:

- Product/service innovations;
- Whether such innovations are either:
    - Incremental,
    - Radical, and/or
    - TEP; and
- Process innovations, either:

        - Technological production, and/or
        - Change in technological input for the same product;
- Organisational innovations;
- Work reorganisation; or
- Productivity innovations.

However, the usage of these indicators takes note of the inter-sectoral/enterprise differences and in particular the concept of "technological paradigm". This concept refers to an outlook, a set of procedures, definitions of the relevant problems and of the specific knowledge related to their solutions. In other words, each technological paradigm therefore defines its own concept of progress based on its specific technological and economic trade-offs as well as institutional and social factors operating as a selection device (Miyazaki, 1995, p. 14).

Thirdly, the technology capability factors are undoubtedly significant in generating and enhancing knowledge. Individually, they are necessary but not sufficient conditions for attainment of technology capability. Given this viewpoint, it becomes crucial to understand how each of these, compared to the other, factors has contributed to S & T knowledge generation and, ultimately, the attainment of technology capability of the (start-up) enterprises in the case of The Innovation Hub. The evidence for the generated S & T knowledge should lie in the application of that knowledge either in turning:

- A novel technical idea into a novel use;
- An already developed technical idea into a novel use;
- A novel technical idea to a familiar use; or
- An established technical idea to an established use where, previously, the attempt resulted in commercial failure.

Fourthly, the underpinnings of the factors driving technological development are of paramount importance when evaluating the technology impact made by The Innovation Hub on the technology capability of the (start-up) enterprises. Two of them are the desire for profit and the need to exercise and maintain (economic) power through acquired technology capability. While the former is necessary, the latter is particularly important because it could be an enabling condition for, or precursor of, the former.

Lastly, policy (performance) management plays a significant role in creating the environment in which technology innovation, diffusion and capability are stimulated. However, the relationship between policy and its outcomes and/or impact is often more difficult to illustrate. In spite of this difficulty, it is important to understand the extent to which the existing policies have created the environment within which technology innovations, diffusion and capability can be enhanced.

2.5 Concluding Remarks

This chapter attempted to illuminate in detail the dynamics underlying technology capability. While its introductory section served as a build-up on the conceptual framework advanced in chapter 1; it equally sought to demonstrate the multifaceted nature of technology capability. It was indicated that such capability is dependent on technology innovation and diffusion as well as the enhancement thereof.

Based on the demonstrated dynamics and dimensions of technology capability, the chapter also discussed the technology capability factors, which are responsible for S & T knowledge generation. Each of the factors (namely, FDIs, R & D and human capital development) in its own right contributes to technology capability. The extent to which one of the three contributes more to technology capability than the others depends on the policy environment and policy performance management.

Based on the critical observations within the context of The Innovation Hub, chapter 3 will outline specific key themes pertinent to assessment of its impact on the technology capability of the (start-up) enterprises. It will also outline the research methodology and approach used in gathering and interpreting data/information on performance of The Innovation Hub.

CHAPTER 3
RESEARCH APPROACH AND METHODOLOGY

3.1 Introduction

As already indicated in chapter 2, technology capability is a complex subject, and an attempt was made to simplify some of the aspects and the key themes. This chapter outlines the approach to the study and presents some plausible thematic performance indicators useful to assess the impact made by The Innovation Hub on technology capability. The indicators are not simply based on the important thrusts highlighted in chapter 2, but are guided by the thematic questions posed in chapter 1, which seek to establish:

- The extent to which policies create the environment within which technology innovations, diffusion and capability can be enhanced;
- The impact made by The Innovation Hub on the technology capability of the technology (start-up) enterprises;
- The (set technologically competitive) indicators against which the (start-up) enterprises and/or The Innovation Hub evaluate their (own) technology capability and progress; and
- How important each technology capability factor (FDI, R & D and human capital development) has been in contributing to the (start-up) enterprises' technology capability.

In addition, this chapter outlines the research road-map, including data collection, analysis and interpretation methods. The significance of having the performance indicators linked to the thematic sets of questions is also highlighted.

3.2 Research Approach

The approach to this study is informed by the Background and Context and the Literature Review discussed in chapters 1 and 2 respectively. Conceptually, this is based on the understanding that "technology capability" refers to the appropriate

competencies to provide technologically based solutions to meet (national or business) requirements and goals. These competencies include the ability to promote and develop a culture of innovation to support long-term sustainable development, economic growth and global competitiveness. These are most often evident in the commercial gains made from product, technological, managerial and organisational innovations. This includes the capacity and ability to competitively absorb whatever market pressure that emanates from:

- The shortening of the product life cycles;
- The rapid emergence of the new products; and
- The product differentiations caused by the rapidity with which technology innovations and changes are occurring.

In other words, technology capability as the desired impact should enable enterprises "to survive over long periods by continuously adapting to the changing environment and by allowing them to enter new product markets" (Miyazaki, 1995, p. 11). Therefore, as part of impact, the (start-up) enterprises should reflect some evident positive change in their business well-being that enabled them "to keep pace with and perhaps occasionally overtake the pack of competitors".

Furthermore, under the Background and Context and the Literature Review, the significance of policy within the context of building technology capability was highlighted. It is necessary to first establish the extent to which the "policy" articulated and pursued the principles that can be linked to attainment of technology capability by the (start-up) enterprises. The approach of linking (government) policy and impact was adopted by Warwick (2000) and Miyazaki (1995) in the fields of "impact analysis" and "competencies in the firm" respectively.

Secondly, as "policy" is thus presumed to represent one of the building blocks in this respect, the approach adopted aimed to assess the Maxum incubation in The Gauteng Innovation Hub, which in a sense represents the policy "implementation" programme. This approach maintains that the Maxum incubation is the specific concrete programme/project translated from policy, or the policy implementation programme.

Thirdly, it is argued that the policy and the Maxum's evident efficacy or attainment of specific goal(s) should be concomitantly linked to systematic "application of knowledge" in:

- providing technologically based solutions;
- promoting and developing the culture of innovation; and
- acquiring commercial gains, hence a need to have technology performance indicators.

The aggregated outcomes of all these partially become synonymous with "impact" because they represent the ultimate desired change(s) in the general state and/or condition of the (start-up) enterprises' business well-being.

Finally, it was illustrated (2.2) that the systematic "application of knowledge" in providing technologically based solutions, promoting and developing the culture of innovation and acquiring commercial gains is complex and delicate yet must be subjected to performance indicators. Despite the inherent challenge in formulating the performance indicators for the impact evaluation, within the context of this study the impact on technology capability should be adequately assessed through, but not limited to, the four cluster indicators extrapolated from the literature reviewed in chapter 2. The following performance indicators were applied to assist in determining the impact of policy and the Maxum incubator on technology capability:

A. Competitive business performance, which refers to one or a combination of the following:

- Organisational innovations;
- Work reorganisation; and
- Productivity.

B. Technical progress, which entails one or a combination of the following:

- Product/service innovations;
- Process innovations; and
- Patented products/services.

C. Effective and growing SET skills, which comprises one or a combination of the following:

- Human capital development levels;
- Participation level in R & D activities; and
- R & D expenditure.

D. Commercialisation or profit-making.

In summarising the issue of the performance indicators, it therefore follows from these indicators that, firstly, the impact of policy on technology capability entails not only innovations and acquisition of technology but also management and organisation factors and management of technologies themselves, as alluded to by Dhungana (2003, p. 9). These indicators are qualitative and difficult to measure quantitatively. They are also closely linked to, and often overlap with, one another, but are separated for analysis and interpretation purposes. Each of them feeds on and is in turn stimulated by the others, hence the idea of the efficacy of the interplay of the technology capability factors. This approach, like Miyazaki's, assumes that technology capability can better be evaluated using statistical (bibliometric) data, patent data and interview (partly self-assessment) data that collectively constitute the performance indicators.

3.3 Research Methodology

3.3.1 Nature of Research Methodology

To emphasise the point made in the introductory chapter, the research took note of the fact that the concept of technology capability building through an incubation programme is a new approach in Gauteng, and still largely untested. As a result, the research made use of a combination of qualitative and quantitative methodologies. However, the focus was mainly on the qualitative, and less quantitative, methodology underpinned by interpretive method so as to accomplish the main objective of this research.

The performance indicators are, on a conventional level, quantitative in nature. The interpretation of these especially within the context of the themes of the interview questions are, on a deep value level, qualitative. To this end, the research methods are based on 5 thematic sets of questions, which are critically examined. Each set is linked

to and responds in a way to the key research questions, and contain mostly open-ended questions and less close-ended questions. The open-ended questions inform the qualitative method; whilst the close-ended questions seek to enhance the qualitative analysis through the extrapolated statistical data. The qualitative questions also contain prospective probability questions intended to probe prospective initiative-centred responses in order to gauge the impact made by The Innovation Hub. Most importantly, this approach also enriched the interpretive analytical tools.

3.3.2 Research Population

The research examined a population of 14 technology start-up companies. This approach is based on a simple premise/rationale that if, indeed, impact represents a set of outcomes of service delivery on a particular target group who are the actual recipients of those services; then one of the valuable ways of evaluating impact should inevitably be by receiving systematic feedback from the target beneficiaries, namely, the (start-up) enterprises themselves. The research therefore targeted 14 enterprises which were chosen from the population of all the start-ups at The Innovation Hub since its establishment and/or those who were ready to go into market testing and production between 2000 and April 2005. This research population excluded the start-up companies which were still in the pre-incubation programme at the time of the research.

As part of the research population, 5 additional persons from GPG and The Innovation Hub were targeted for interviews. The sample group in this regard comprised mainly policy-makers and advisors in the field of S & T, who could be regarded as key informants. The main purpose of these additional interviews was to capture a wide spectrum of views on the impact of policy on technology capability in The Innovation Hub. They assisted in providing the policy implementation and/or programme perspectives and determining the validity and reliability of the gathered data, particularly in the analysis and interpretation thereof.

The total of enterprises and people targeted for interviews was 19 in number and had been randomly selected. Their accessibility, both physically and electronically, had been one of the major determining criteria.

3.3.3 Data Collection

The gathering of the empirical data/information was in the main centred on the questions grouped into 5 themes. The preliminary set of questions was pilot tested amongst 4 companies and 2 individuals. Each of the target respondents reviewed the questions and provided feedback regarding their wording, clarity and applicability. The pre-testing of the questions further assisted in determining the rationale for each question asked.

The main part of the data collection method took the form of face-to-face in-depth interviews. These were administered by the author and all the members of the research population were visited at their business premises. Most of the follow-ups on issues raised during the interviews were done telephonically.

The interviews were based on the revised set of questions that had few structured response categories. The questions with the structured response categories were balanced with the open-ended questions in order to solicit more qualitative data/information. Though the respondents might have not had sufficient time to reflect on the questions; this method provided the opportunity to probe for details and to clarify questions, as and when necessary. Intrinsically, this method ensured that everyone understood the questions in the same way as the interviews were administered by the same person with the same level of command of the subject matter.

However, the major challenge in this regard was often to categorically quantify information and to consistently standardise data reduction. This challenge emanates from somewhat overwhelming open-ended responses, confirmed by the number of telephonic follow-ups made.

3.3.4 Data Collation and Analysis

The diverse international experience, as already illustrated in chapter 2, indicates that "impact" is generally influenced by a wide range of factors, which may not fall entirely

within the control or accountability of one institution, programme or project. Therefore, the collation and analysis of data for critical evaluation of "impact" may inherently require critical assessment of the outcomes of several factors across the different sources. In view of this, it was decided to use the following five broad thematic sets of questions (to be detailed in the next chapter when presenting the findings) not simply to identify the sources of impact but to critically evaluate the "impact" of policy on "technology capability" in The Innovation Hub:

- *The (start-up) Enterprise Technology Status*

The objective of this set of questions is to apply time-lag relationship in order to reflect the technological status of the (start-up) enterprises between their original technology priorities, objective for coming to The Innovation Hub and their actual/accomplished technological or commercial outcome(s). Simply put, this seeks to determine the form of positive business change or accomplished technological and commercial goals. The majority of data solicited through the set of questions is statistically quantitative. The proposition to be examined in this regard is that the start-up enterprises acquired a positive business change as a result of their involvement in the Maxum incubation in The Innovation Hub. Data of this nature therefore require an analysis of trends/statistics that emanate from the first, second and fourth thematic sets of performance indicators.

- *The Policy Environment*

The objective of this set of questions is to determine the extent to which the government policy has created an enabling environment for the start-up enterprises to successfully innovate and/or commercialise technology. The data required under the policy environment-related questions is both quantitative in terms of Lickert scale responses or frequent choices in optional questions, and qualitative in terms of open-ended responses. There is also an attempt to not simply link responses back and forward but also to verify/confirm consistency of responses. The proposition to be critically examined in this regard is that where government creates an enabling environment, the start-ups generally innovate and/or commercialise technology. The analytical tool applied for this set of questions is largely interpretive as the majority of the questions under this theme are open-ended.

- *The Maxum Incubation as a Technology Capability Building Agency*

The set of questions on the Maxum incubation centred on the effectiveness of The Hub in implementing the policy and providing the required support for the start-up enterprises to attain technology capability, i.e. the efficacy of the Maxum incubation. Almost like the policy environment-related set of questions, this set of questions requires both less quantitative data, in terms of rating-centred responses, and more qualitative data in terms of open-ended questions. The proposition critically scrutinised through this set of questions is that the Maxum incubation, like many other incubators, effectively provides the necessary support for building the technology capability of the (start-up) enterprises.

- *The Importance of the Technology Capability Factors*

The objective of the set of questions on technology capability factors is to assess the importance of each, and/or an interplay of combinations of the three factors in ensuring that the (start-up) enterprises achieve competitive technology capability. Because of the magnitude of work inherent in assessing the importance of these factors, the data required under this set of questions is largely quantitative. The proposition critically examined in this regard is that, if well managed, the technology capability factors equally contribute to attainment of technology capability. Much of the information in this regard is interpreted within the context of the third thematic set of performance indicators.

- *Impact Evaluation*

Based on data gathered under the previous sets of questions, the impact evaluation-centred set of questions seeks to establish whether the start-up enterprises managed to commercialise their innovations. Competitive sustainability is a critical feature of technology capability. Given the significance of sustainability, this set comprises questions that probe the probability and prospects of initiating new ventures/projects. Responses to these questions examine the long-term implications of being involved in the Maxum incubation in The Innovation Hub and thus enhance the evaluation of impact. Given the definition of technology capability outlined earlier, it is crucial to determine whether the enterprises commercialised their technologically-based solutions as a result of their involvement in The Innovation Hub. The evidence for this

theme lies in the data that reflect a sequential move from first and second sets of performance indicators to the fourth set of indicators.

3.3.5 Limitations of the Research Methodology

One of the obvious limitations of the adopted research methodology and approach is that The Innovation Hub is a neophyte. This compromises its actual "impact" because only the medium-term effects of The Innovation Hub could be fairly ascertained. The long-term effect of The Innovation Hub can only be extrapolated on the basis of the medium-term effect. Nonetheless, the study is necessary as The Innovation Hub is still a pilot programme.

Another limitation of the research methodology and approach is accessibility of the targeted research population. In certain instances, sufficient time for interviews was not provided by the interviewees, which compromised the quality of information provided.

There was some difficulty in fairly classifying the gathered data due to complex and overlapping information. This means that some personal bias could have unconsciously manifested itself in the classifying, and the interpreting of the data.

The non-entrepreneurs (or GPG/Hub's officials) were used to find out more, or validate, information. They may have influenced the findings to an extent, since some of them were part of the management of The Innovation Hub.

3.4 Conclusion

This chapter has outlined the approach to the study, not only providing the definition of the key concept, namely, technology capability, but also providing indicators to measure attainment thereof. These indicators were categorised into themes that are closely related to the thematic sets of questions.

Based on this approach, the next chapter will present the findings. It will also provide a solid foundation for analysis and interpretation of the findings in chapter 5.

CHAPTER 4
PRESENTATION OF THE FINDINGS

4.1 Introduction

Chapter 2 reviewed the literature on technology capability building with the aim of highlighting international approaches and experiences. Based on the important lessons drawn from different international initiatives, the questions raised under the Problem Statement were examined in order to shed light on the impact of "technology capability" of The Innovation Hub. Chapter 3 then outlined the research methodology used to gather data/information and to assess the quality impact of technology capability initiatives in The Innovation Hub. The chapter also highlighted some of the research propositions and technology capability indicators considered appropriate to critically evaluate the impact of policy on technology capability in The Gauteng Innovation Hub.

Logically, this approach helped in setting a framework for presentation, interpretation, analysis and comprehension of the findings. As a result, the focus in this chapter shifts to presentation of the findings in keeping with the international experiences and lessons, on one hand, and, on the other, the methodology and performance indicators presented in chapters 2 and 3 respectively. The presentation of the findings is made along the five thematic questions and/or propositions, with each followed by its respective observations. The set of primary questions used for gathering data/information is attached as Annexure A.

4.2 Data Presentation and Findings

The initial target research population comprised 14 (start-up) enterprises and 5 additional persons. The selected enterprises either previously participated, or were still involved, in the business activities of The Innovation Hub at the time of this research study. Seven (50%) of the targeted 14 enterprises, which participated in the research study, were still in the Maxum incubation programme at the time of the study. Most of

these enterprises had been in the programme for less than 3 years, and were helpful in providing information on the immediate value derived from the Maxum incubator. They were classified under the "enterprise creation and development" phase. A list is attached as Annexure B1.

The other 7 (50%) of the remaining targeted enterprises had either already graduated from the Maxum incubation programme, had been involved in the other programmes of the Hub and/or had left the programme. This group of enterprises was therefore categorised into the third phase of the incubation programme, namely the "market development" and is attached as Annexure B2. The majority of these enterprises had been in The Innovation Hub since its inception in 2000 and were in the "enterprise" section of The Hub.

However, 2 (28.6%) of the 7 targeted enterprises in the "market development" phase (namely, World Wide Objects and Bestphone, which were among the first to join the Hub), were no longer in operation at the time of this study. Notably, 1 of the 2 envisaged, yet unsuccessful, replacements (namely Esay Programme cc) of the initial tenants in the Hub was opened in United Kingdom (UK). However, the enterprise had already closed its South African office at the time of this study. One (20%) of the 5 actual participant enterprises in this category had no further business dealings with The Innovation Hub, and had prematurely left The Innovation Hub and relocated to Potchefstroom (North-West Province). Furthermore, Grintech is the only (start-up) enterprise which did not participate in the research despite the fact that it was one of the examples highlighted as a key achievement of The Innovation Hub in section 1.4.1.

Therefore, only 12 (85.7%) of the 14 targeted (start-up) enterprises participated in the research study. Five (41.7%) of these 12 enterprises were very helpful in providing perspectives on the long-term outcomes or impact made by The Innovation Hub in relation to their technology capability. Seven (58.3%) of the 12 participant (start-up) enterprises were particularly helpful in providing impact signals of The Innovation Hub's performance.

Only 2 (40%) of the 5 targeted additional persons from GPG and The Innovation Hub were interviewed. One (50%) of the 2 persons was the official of The Innovation Hub

and the other 1 (50%) was the former GPG official who had been involved in the establishment of The Innovation Hub. These persons also participated when the preliminary set of the questions was pilot-tested. Their assistance proved indispensable as it contributed towards a broad perspective on the building of technology capability. Only 14 (73.7%) of the 19 targeted research population actually participated in the research study.

4.2.1 The (start-up) Enterprise Technology Status

The objective of this thematic set of questions was to portray the technological status of the (start-up) enterprises in relation to their original technology priorities, objective(s) for coming to The Innovation Hub and the technological or commercial outcomes.

- *The Objectives for Coming to The Innovation Hub*

The findings in this respect demonstrate the (start-up) enterprises' original technology priorities through a selection of the objectives for coming to The Innovation Hub. This approach was helpful when critically assessing their actual technological or commercial outcome(s), as the following table illustrates:

Variables	***No of Com-panies***	***No of Variable Overlaps***	***Variable Relat-ionships***
Turn a novel technical idea into novel product/service	*4*	*3*	*1C and 2D*
Move a technical idea to its commercialization	*2*	*1*	*1D*
Turn an already developed technical idea into novel product/service	*3*	*1*	*1A*
Move an already developed technical idea and/or product/service into commercialization	*7*	*3*	*2A and 1B*
Turn a novel technical idea to a familiar use	*0*	*0*	*0*

Notably, almost all enterprises came to The Innovation Hub because of the concept of "innovation" that underpins the above-mentioned variables and in particular the fourth variable. This was attested not simply by the level of overlaps in choosing the objectives as depicted in Column 3 (No. of Variable Overlaps), but more significantly, most of the enterprises claimed to have been attracted by the concept "innovation".

The words 'innovation' and 'indigenous' have frequently featured in the policy and strategic documents of the new democratic government. For example, one of the founding documents of The Innovation Hub has clearly articulated a policy thrust of "local proprietary knowledge", echoed in one of the three pillars of the NRDS. The above table clearly indicates and confirms an appreciation of the "indigenous smart" S & T principle for economic impact. The notion of science and technology for economic impact is also advocated by the recently established DST.

More significantly, the incentive for coming to The Innovation Hub was the less costly "office space". This fact was confirmed by 8 (66.7%) of the 12 enterprises. The provision of "affordable" office space can be seen as a policy implementation aspect in pursuit of the goals and objectives set out in the DTI's Advanced Manufacturing Technology Strategy (AMTS). One of the goals/objectives is to facilitate the building

of a conducive environment for innovation, particularly through the supply of skilled human resources, technology infrastructure and funds.

- *The Main Technology Innovations*

Regarding the main technology innovations, all of the (start-up) enterprises are in the information communication technology sector. However, they can be distinguished, on one hand, by whether they are in the telecommunications electronics or software. On the other, they may also be distinguished by whether they are in the service provision sector or product innovation sector. The product innovation sector ranges from innovative product design and development and customisation of the existing products, to open source development. To this end, the main technology innovations in The Innovation Hub can be pronounced as being in tune with the DTI's Integrated Manufacturing Strategy (IMS). IMS recognises that South Africa's future competitiveness depends on "the capacity of the manufacturing sector to master advanced technology domains, to innovate and to meet the precise needs of customers" (AMTS, p.3).

Surprisingly, there is lack of participation by non-ICT (start-up) enterprises. This was found to be contrary to acceptance policy of The Innovation Hub, which encouraged start-ups from diverse sectors to join it. For example, the start-ups in biotechnology and advanced material, to mention but a few, are also welcomed.

- *The Enterprises' own Technology Performance Indicators*

Based on the inputs of the (start-up) enterprises during the interviews, the following are the summarised and categorised key performance indicators used by the enterprises to measure their technological progress and/or capability. The list is not exhaustive, but is illustrative of the enterprises' own key performance indicators.

A. Successful product/service innovations that meet the market needs;
B. The unique value added by the innovative products/services;
C. The ability of the innovative products/services to meet the professional portfolio standards/norms;
D. Regular consumption/application by the target consumer group;
E. Profit-making; and
F. Sustainability of their business and/or growth of the market share.

In light of this list, it could be expressly suggested that the enterprises' indicators are largely market-orientated. This finding is supported by points B, D and F. By and large, these market-centred dimensions could be linked to, as they determine, the fourth performance indicator, namely, profit-making. Furthermore, point C could be associated with patentability of innovations, which is one of the indicators for "competitiveness".

- *Technological Progress*

Progress can be better measured where there are priorities and performance indicators. In view of the objectives, the main technology innovations and the technology performance indicators outlined above, the following table illustrates the ratings made by the (start-up) enterprises since joining The Innovation Hub and/or the Maxum incubation programme, and demonstrate to a considerable extent the technological progress made by the start-ups:

Variable	***VE***	***E***	***LE***	***NE***
Product/service innovations	*8 (66.7%)*	*4 (33.3%)*	*0 (0%)*	*0 (0%)*
Process technology innovations	*2 (16.7%)*	*5 (41.7%)*	*3 (25%)*	*2 (16.7%)*
Organisational innovations	*1 (8.3%)*	*4 (33.3%)*	*5 (41.7%)*	*2 (16.7%)*
Work reorganization	*4 (33.3%)*	*5 (41.7%)*	*2 (16.7%)*	*0 (0%)*
Productivity	*2 (16.7%)*	*3 (25%)*	*4 (33.3%)*	*3 (33.3%)*

Note.: Mnemonic symbols are used in this table. VE = very effective, E = effective, LE = less effective and NE = not effective. Both VE and E represent positiveness, with VE representing the highest level of positiveness and E representing ordinary level of positiveness. Similarly, both LE and NE represent negativity, with NE representing the worst level of negativity and LE representing ordinary negativity.

- *The Key Observations*

Because almost all enterprises came to The Innovation Hub because of “affordable office space"; it was found that The Hub alleviates the start-up hurdle of costly office space in the business market. In other words, as previously mentioned, “affordable office space” is an enabling condition that facilitates innovation.

The data/information presented presuppose a close relationship between the enterprises’ objectives for coming to The Innovation Hub and technological innovation progress made since joining The Hub. For example, 7 (58.3%) of the enterprises came to The Innovation Hub with the objective of moving an already developed technical idea and/or product/service into commercialisation. It is interesting that 8 (66.7%) of the enterprises rated their technological progress in terms of “product/service innovations”. This correlation presupposes that the key performance indicator for the start-ups is commercialisation of innovated products/services. This finding corroborates the point made in chapter 2 that: “it is only by upgrading of technology (innovation) that there could be new technology capabilities that respond to market needs and determinants ... acquired by the technologically successful (start-up) enterprises”.

Of the 4 (80%) out of 5 enterprises that commented extensively on technological progress and happened to be in the market development phase; 2 (50%) of them emphatically indicated that their organisational innovations were largely as a result of a mixture of business and market growth factors. They either had to respond to or attempt to seize the identified market opportunities. In terms of the skill factor, the internal skills, especially where a particular required skill is non-existent or scarce, were the drivers. Furthermore, organisational innovations were also influenced by entrepreneurial exposure to how other competitors function structurally. This could be attributed to the opportunity to network provided through the marketing activities of The Innovation Hub.

Process innovations were found to be existent largely in enterprises that specialise in customisation of products/services. A clear example of customisation of product was evident in the development of software that linked a rural clinic with both a regional hospital and a laboratory in order to ensure speedy results of blood test samples from

the rural village. Based on this finding, the innovations in this regard were "incremental" as they reflected "small modifications … with at most minor changes in work organisation" (Miles, 1994).

At face value it could be strongly argued that The Innovation Hub:

A. Indeed serves as the point of intersection between ideas and action, between innovation and entrepreneurship; and
B. Unlocks the country's economic potential in chosen areas, particularly economic renewal in Gauteng.

4.2.2 The Policy Environment

Besides the fact that The Innovation Hub is itself a policy implementation programme, there was a need to determine the extent to which government policies have generally enhanced, rather than impeded, competitive technology innovations or capabilities. The findings made with respect to the policy environment are depicted through what was regarded as the conducive policy environment, the performance of policy, the enabling policy aspects and the policy aspects that need to be improved. Due to the inseparable nature of these dimensions, the findings are presented at the end of this subsection (4.2.2).

- *The Conducive Policy Environment*

The following are the aggregately summarised variables, regarded by the enterprises as important when making the policy environment conducive for technology innovation and/or commercialisation:

A. More start-up capital/seed funding;
B. Co-ordinated integration and sustainable implementation of government support/development programmes;
C. Protection of the prioritised sectors at the start-up level coupled with systematic gradual exposure to international competition;
D. Consistent monitoring of the technological innovation progress from idea to at least first product;
E. Clear M & E system with clearly defined performance indicators, outputs and outcomes; and

F. The state refunding and legal protection of any successful technological innovation with potentially vibrant commercial success.

All these variables are generally underscored by a simple rationale that (ICT) products take a long time to innovate, develop and get to the market. This process makes affordability difficult, especially in the absence of any coherent M & E system.

- *The Performance of the Policy Environment*

Regarding the extent to which government policies have created an environment that enabled the (start-up) enterprise to innovate and/or commercialise technology:

A. 3 (25%) of the enterprises rated it as very effective;
B. 6 (50%) of the enterprises rated it as effective;
C. 2 (16.7%) of the enterprises rated it as less effective; and
D. 1 (8.3%) of the enterprises rated it as not effective.

One major reason for one of the enterprises to rate the policy environment LE was the effect of the implementation of BEE and its discouraging implications for white technological innovators. This suggests that as much as government wants to redress entrepreneurial inequalities, it should not compromise the value added by the already advanced white entrepreneurs.

- *The Enabling Policy Aspects*

A. Innovation encouraged and supported programmes established by government; and
B. The government goals such as the 2014 Vision which prioritises the development and growth of the SMEs.

- *The Policy Aspects to be Improved*

A. Commensurate resource allocation in accordance with the political and policy decisions;
B. Incentive structure designed for promotion and protection of indigenous technology innovations;
C. Co-ordinated and integrated implementation of various government programmes; and

D. Consistent independent monitoring and evaluation of the operations and impact of government support programmes.

- *The Key Observations*

Interestingly, while 8 (66.7%) of the 12 enterprises did not view The Innovation Hub within the context of policy implementation, those who viewed it as such have provided quality information. For example, one enterprise emphatically maintained that, if GPG really wants to optimally utilise The Innovation Hub as part of the economic turnaround strategy, then that opportunity lies in the co-ordinated integration and implementation of various government programmes. On one level, the co-ordinated integration and implementation approach suggests that SMEs have not become the essential role-players in moving from low-end S & T applications to more sophisticated S & T applications as in Malaysia. The rationale would not simply be to support government programmes but rather to provide the (start-up) enterprises with the necessary opportunity to apply and test their technology capabilities. The best scientific formula to build and manage technology capability starts with a clear appreciation of one's technological situation, that is, promoting appreciation of the technology situation of Gauteng and South Africa.

On another level, lack of co-ordinated integration and implementation approach presupposes The Innovation Hub's failure in exploiting the existing government support programmes to the benefit of the start-ups. For example, the WPST (1996) set "improved support" for all kinds of innovation which is fundamental to sustainable economic growth. In an attempt to concretise this "specific goal" through strategic allocation and management of resources; government introduced a clear single point of strategic direction based on a number of financing instruments (Innovation Fund, SPII, and PII, for example) and technology diffusion and transfer programmes (Tsumisano, GODISA and NAMAC, among others). On the contrary, the start-ups have not yet benefited from a clearer single point of strategic direction of funding, co-ordination and integration. In other words, The Innovation Hub should have had the capacity to identify, co-ordinate and finance the new technology and innovation for start-up enterprises as articulated by the NRDS (2002, p. 33) in order to make a meaningful "impact" on the technology capability in the province.

4.2.3 The Maxum Incubation as a Technology Capability Building Agency

The "efficacy" of The Hub in implementing the policy and providing the required support for start-ups to attain technology capability could not have been done using only one of the four dimensions outlined below. The level of performance influences the degree of "success" and the two are dependent on the enabling aspects, which pre-supposes identifying those aspects that need to be improved.

- *The Success Rate of the Maxum Incubator*

Generally, all the enterprises acknowledged that, given that the Maxum Incubator has started only in 2003, it was generally difficult to determine its long-term quality impact. However, regarding the extent to which it has succeeded in facilitating technology innovation and/or capability building,

A. 2 (16.7%) of the enterprises rated it as very effective;
B. 4 (33.3%) of the enterprises rated it as effective;
C. 4 (33.3%) of the enterprises rated it as less effective; and
D. 2 (16.7%) of the enterprises rated it as not effective.

The success in this respect was largely based on the medium term effects as construed from the statistical data rather than the long term quality effects.

- *The Incubator's Enabling Aspects*

The following are the factors generally regarded as having enabled the enterprises to innovate and/or commercialise their technology initiatives:

A. Discounted services that make innovation and commercialisation relatively affordable;
B. Mentorship under highly exposed/experienced experts;
C. Marketing activities that help raise the promotion of the tenant companies;
D. Networking that makes access to many like-minded people easy;
E. Entrepreneurial development;
F. Credibility of being at the "right address" and being vetted for entry; and
G. Easy access to information.

- *Aspects of the Incubator to be Improved*

Aspects of the Incubator that need to be improved or changed in order to better help the enterprises build technology capability included:

A. Formal access to capital investment and grant funding channels; despite the NRDS's position that IF will play a crucial role nearer to the market in developing product or service concepts and financing development of research concepts into prototype products, the start-ups still encounter enormous financial constraints in this respect;
B. Centralised marketing initiatives for newly innovative products/services;
C. Lower costs to (start-up) companies especially in lean times;
D. Provision of legal support services especially with regard to intellectual property rights (IPR) and business contracts (NRDS, 2002, p. 34) advocates for the development of the institutional capacity to manage intellectual property, especially intellectual property derived from publicly financed research and innovation. It further recognises that, for the start-ups, the ability to secure intellectual property often competes (in budget terms) with other costs such as salaries; and
E. Balancing academic experience with business experience.

- *The Incubator's Level of Performance*

The following table reflects the Maxum Incubator's level of performance according to the (start-up) enterprises. Whereas the rating for success was on a high level, the ratings in this case focus on the various elements of technology innovation:

VARIABLES	***VE***	***E***	***LE***	***NE***
Turning a novel technical idea into a novel product/service	*1 (8.3%)*	*3 (25%)*	*5 (41.7%)*	*3 (25%)*
Move a technical idea through to its commercialization	*2 (16.7%)*	*7 (58.3%)*	*2 (16.7%)*	*1 (8.3%)*
Turn an already developed technical idea into a novel product/service	*3 (25%)*	*6 (50%)*	*3 (25%)*	*0 (0%)*
Move an already developed technical idea into commercialization	*3 (25%)*	*9 (75%)*	*0 (0%)*	*0 (0%)*
Turn a novel technical idea to a familiar use	*0 (0%)*	*0 (0%)*	*0 (0%)*	*0 (0%)*

- *The Key Observations*

In general, the success rate of the Maxum Incubator statistically appears to be equitably rated as effective (4) and less effective (4). Statistically, this represents average performance, but in terms of the Maxum incubator's level of performance with regard to specific technology innovation variables, 9 enterprises rated it effective on moving an already developed technical idea into commercialisation. This rating reflects some correlation between the objective for coming to The Innovation Hub (as explained under 4.2.1) and the performance of The Innovation Hub in this respect.

The follow-up questions have revealed that because of the state-of-the-art infrastructure in The Innovation Hub's new premises, the office space has become expensive. Interestingly, the level of cost of The Innovation Hub was largely felt by the enterprises in the "market development" phase. These groups compared the current renting expenses to the past renting expenses when The Innovation Hub had been based in the CSIR premises.

It was interesting to note that The Innovation Hub does not have a performance management system for monitoring and evaluating technology innovations and/or capability. Inevitably, in the absence of such a system, it would logically be difficult

to assess what start-ups had accomplished within the context of The Hub's performance indicators. Unlike in other government-supported programmes where annual reports account for actual outputs/deliverables against the set performance measures/indicators and targets; The Innovation Hub's annual reports do not include such variables.

4.2.4 The Importance of the Technology Capability Factors

Under section 2.3, it was highlighted that technology capability factors manifest a symbiotic relationship, with each feeding on and in turn being stimulated by the others in the process of building technology capability. This point posits that on the actual outcomes/impact level, a similar relationship does occur. There is thus a close relationship between this subsection and the subsequent one (4.2.5). Nonetheless, this subsection focuses largely on the importance of each, and/or an interplay of the combination, of them in ensuring that the start-ups achieve competitive technology capability.

- *The Flow of SET Knowledge*

The (start-up) enterprises rated the performance of The Innovation Hub with respect to the flow of SET knowledge as follows:

A. 1 (8.3%) rated it as very effective;
B. 2 (16.7%) rated it as effective;
C. 4 (33.3%) rated it as less effective; and
D. 7 (58.3%) rated it as not effective.

The performance of The Innovation Hub in this regard is in sharp contrast with a number of policy thrusts. On one hand, the NRDS cautions that without proper integration, each programme develops its own criteria and method, and, obviously, without the ability to learn from others and effectively channel resources to the best opportunities, there are duplications, fragmentation and wastage of resources. On another level, this finding is in sharp contrast with the AMTS' (p. 7) goal/objective of facilitating "the flow of technological resources to industry through new knowledge networks to foster innovation".

- *The Importance of the Technology Capability Factors*

The following table illustrates the importance of the factors:

FACTORS	***VI***	***I***	***LI***	***NI***
FDIs	*1 (8.3%)*	*4 (33.3%)*	*5 (41.7%)*	*2 (16.7%)*
R & D	*0 (0%)*	*2 (16.7%)*	*6 (50%)*	*4 (41.7%)*
HCD	*2 (16.7%)*	*5 (41.7%)*	*4 (33.3%)*	*1 (8.3%)*
Integration	*0 (0%)*	*3 (25%)*	*6 (50%)*	*3 (25%)*

Note: The mnemonic symbols VI = very important, I = important, LI = less important and NI = not important. The same principles outlined under table 2 are applied in this table to assess the level of performance of the technology capability factors.

- *The Key Observations*

Taking the statistical information above, The Innovation Hub appears to be dismally underperforming in respect of the technology capability factors. None of the four variables of the performance on the flow of SET knowledge were positively rated higher and R & D was the worst. Contrary to the NPDC's strengthened capacity to provide R & D on emerging technology areas, such as Virtual Prototyping as articulated by AMTS (p. 14); the enterprise specialising in Virtual Realities could not access the NPDC's services. This finding supports the non-linear R & D model which holds that R & D is subordinate to innovation, in that it is one of the activities which can contribute to technological change. The case in point has been the ASEAN NICs' industrialisation which was initially predicated not on local innovation, but on accessing technology from abroad.

While the performance ratings of the FDIs are low, the R & D findings imply that the FDIs were helpful in attaining technology innovations in the absence of the positive R

& D process. Follow-up questions, however, revealed different results. The FDIs as a strategy for S & T knowledge transfer, absorption and application appeared to be performing qualitatively rather than quantitatively. For example, the Innov8, which is responsible for networking and business linkage, started in 2000 with about 4 participants and now has about 4 500 participating members. In substantiating the importance of this programme, one particular enterprise in the "market development" phase clearly indicated that it had a business deal with Media Maestirri company from Finland as a result of The Innovation Hub. Another enterprise clearly indicated that one source of process innovation was based on extensive and in-depth experience enjoyed under the mentorship programme, confirmed by, amongst others, the deployment of an experienced professor from the CSIR to The Innovation Hub.

As The Innovation Hub is the first internationally accredited science park in Africa and a member of the International Association of Science Parks (IASP) its name is highly recognised as the S & T brand. Eight (66.7%) of the 12 enterprises have clearly indicated that they use this brand in order to have significant business dealings. However, 4 (33.3%) of the enterprises, all of which have already graduated from the Maxum, also clearly indicated that the "unique internal capability" or "customer-oriented solutions" are fundamental when utilising The Hub as S & T brand. This group of enterprises represents 80% of the enterprises involved in the "market development" phase.

All enterprises acknowledged that "unique internal capabilities" serve as incentive or source or interest for either business collaboration/partnership (FDIs) or funding for R & D.

The call for "Balancing academic experience with business experience" under section 4.2.3 indicates that The Innovation Hub overlooked "entrepreneurial" skills. There is no fully-fledged "entrepreneurial development" programme dedicated to equip the entrepreneurs with business skills. The word "entrepreneur(ship) appeared only 1, 4 and 6 times in the AMPTS, NRDS and WPST respectively, despite the fact that WPST talks explicitly of "the entrepreneur support" the fifth time. On a deep value level, this observation suggests that the (start-up) entrepreneurs' extensive SET achievements do

not automatically translate into entrepreneurial achievement. In other words, technology capability is dependent on SET innovations as much as it is dependent on "entrepreneurial" skills.

4.2.5 Impact Evaluation

Though this thematic set of questions was grouped separately from the preceding questions; it mainly served to follow up and qualitatively validate responses provided in them. The obvious cases in point are the first two questions.

With reference to the "commercial gains" aspect of "technology capability", already defined as one aspect of "impact"; there is an element of hybrid/mixed success. On one hand, all of the 4 start-up enterprises that were still in The Innovation Hub have been satisfied with their commercialisation successes. One of these went to the extent of indicating that its financial transactions were mainly dollar-based and mainly with UNESCO. On the other hand, the enterprise that had prematurely left The Innovation Hub was equally satisfied with its commercial successes, and indicated that it has achieved greater success than it would have done had it remained in The Innovation Hub. Given this apparent dichotomy of views, the key question is whether the commercial successes of the enterprises that were still in The Innovation Hub could indeed be explained in terms of the role played by The Hub.

Furthermore, this hybrid of successes was found in respect of provision of the "technologically based solutions … to support long-term sustainable development" aspect of "technology capability". All of the 5 enterprises in the "market development" have clearly indicated that they would definitely venture into new technology initiatives. With regard to the 4 enterprises that are still in the Hub, this might suggest that The Innovation Hub might have developed and equipped them with the necessary business confidence. However, this viewpoint relating to the efficacy of The Hub might need to be scrutinised more carefully, especially given the business competitiveness displayed by the enterprise that had left The Innovation Hub prematurely. In the case of this enterprise, business confidence is not a sufficient condition for business competitiveness. Most significantly, the enterprise's self-

sustenance is one of the key performance indicators for technology capability, particularly the competitive aspect.

With regard to the "ability to promote and develop a culture of innovation" aspect of "technology capability", it was found that The Innovation Hub might have achieved this requirement. The evidence to this effect is based on the implication of the finding made in the supra-paragraph. In other words, it could be said that The Innovation Hub had achieved the desired change(s) in the general state and/or condition of (business) well-being of the (start-up) enterprises. However, based upon these findings, there is a need to further examine whether these findings are in keeping with the performance indicators and literature review outlined in chapters 2 and 3.

In conclusion, the major finding is that government programmes should be informed and guided by need when supporting and developing technology capability instead of simplistically focusing energy on technology in general. This did not appear to be the case at the time of the study. Within the context of the (start-up) enterprises, this approach would, in future, specifically help the enterprises with the identification of the real "market" need and the development of the "necessary" products to address that need, as was strongly argued by the enterprise that had prematurely left The Innovation Hub.

4.3 Summary of the Key Findings

The summary is guided, and based upon, the data presented and the findings outlined in the previous sub-sections (4.2.1-5). Presentation of the key findings in this section is done along the 4 broad performance indicators: competitive business performance, technical progress, effective and growing SET skills, and commercialisation or profit/making. The key findings may be summarised as follows:

- *Competitive Business Performance*

As already acknowledged, it may be difficult, if not hotly contested, to conclusively argue that the enterprises, especially those that are in the "market development" phase of The Innovation Hub, have already attained a culture of innovation. Nonetheless, the enterprises have, beyond reasonable doubt, developed, grown and become more

competitive compared to their initial contact with The Innovation Hub. For example, some of them have had an increase in staff complement, such as one black-owned company whose staff members increased from 4 in 2000 to 13 by March 2005. Regarding competitiveness, besides the company that prides itself on collaboration with the Finnish company, another company specialising in educative virtual realities has experienced "unexpected business successes" particularly in other African countries. Following these positive quality changes, it would be reasonable to conclude that The Innovation Hub has made a meaningful impact on the technology capability of the (start-up) enterprises.

With special reference to the literature review, this finding is in sharp contrast with Chang's (1998, p. 98) point. The "competitive business performance" of the (start-up) enterprises was in this respect not as a result of the TNCs' internal capabilities that contributed towards the start-ups' S & T knowledge. Collaboration with international enterprises were minimal. Therefore, the evidence of this nature corroborates Dhungana's (2003, p. 12) point that self-reliance coupled with the increase in demand are necessary conditions for technology capability building.

However, a gap in these positive quality changes is the inability to tell whether the enterprises' identified development is sustainable in the long-term, especially when leaving The Innovation Hub. Put differently, the possible gap is, on one hand, the inability to ascertain that the enterprises' economic growth is concomitantly translated into productivity. On the other hand, while some enterprises proved to be competitive in Africa; the key question is whether they will remain globally competitive, especially in the developed economy countries. Reluctance to uphold the enterprises' "sustainability" is exacerbated by the observation that one enterprise should already have left The Innovation Hub in terms of the 5 year tenancy agreement but, by the time of this study, this had not happened.

- *Technical Progress*

All of the 5 enterprises in the "market development" phase have in their own way succeeded in their product/service innovations, although these innovations were largely incremental. This is supported by the fact that most of them spoke of "customisation of product development", which suggests that, as their innovations were not radical

(not to mention revolutionary), there were fewer changes involved in production processes and there were no new products which could establish new markets or displace familiar products from established markets (Miles, 1994). As will be further demonstrated below, the technology capability factors, especially FDIs, are necessary but not sufficient conditions for attainment of technology capability. This implies that the successful innovations were by and large indigenous.

Competition is on either the basis of superior technical knowledge, low cost, natural resources or on the basis of higher efficiency of some kind. If this is correct and South Africa is indeed increasingly competing on the basis of good technical knowledge, then Miyazaki's (1995, p. 28) argument holds water. He maintains that a period of trial, error, learning and associated incremental change is necessary before a major new technology begins to reach its potential, and this appears to be a precise description of what is happening in The Innovation Hub.

- *Effective and Growing SET Skills*

The effectiveness of the SET skills could, on a conventional level, be evidently manifested in the technical progress attained by the enterprises. However, on a deep value level, this was found to be misguided because most of the entrepreneurs who came to The Innovation Hub had had extensive prior academic SET, and some relatively less business experience. Some of the entrepreneurs complained about the lack of entrepreneurial capacity-building. This finding is contrary to the Annual Report's (2002/03, p. 19) articulation that the purpose of the incubation phase is to stimulate and facilitate the growth and sustainability of knowledge-intensive and technologically innovative start-ups in a synergistic environment where entrepreneurs are sharing, learning, creating working partnerships and doing business together with the objective of spurring local economic development and commercialising scientific or academic findings.

Furthermore, given that there were no meaningful capacitating foreign investments, the fact that the enterprises' SET skills emanated from trial-and-error undermines the argument that technological activities in general are frequently drawn toward countries with evident relevant technological advantages or technological potential. Alternatively, this experience might also be undermining the extent to which existing

policies have created the environment within which technology innovations, diffusion and capability can be enhanced. This dimension partly supports the view that innovations embody or draw on a wider range of constituent technologies and knowledge bases already in existence. Based on these findings it could be argued that in the final analysis Sung et al's (2003) point that the main objective of the science parks and/or incubators is most often to promote the application of science by bridging the gap between R & D and commercialisation of scientific and academic findings was not fulfilled.

- *Commercialisation or profit-making*

Though enterprises could not have revealed their financial status, all of them appeared to have succeeded in making profit out of their innovative products. What remains unknown is the extent to which the acquired technology capability as the desired impact will enable the enterprises "to survive over long periods by continuously adapting to the changing environment and by allowing them to enter new product markets".

In terms of the transversal effect, The Innovation Hub, like any science park, is expected to stimulate and manage the flow of knowledge and technology amongst universities, R & D institutions, companies and markets. Therefore, one of the main objectives of The Innovation Hub should have been promotion of the generation and application of SET knowledge by bridging the gap between R & D and commercialisation of entrepreneurial and academic findings. The co-ordinated optimal utilization of the flow of SET knowledge amongst these role-players was to a large extent poor. This shortfall calls for co-ordinated integration and sustainable implementation of government support/development programmes.

The other important findings are in the main related to generation and application of entrepreneurial-based SET knowledge. For example, the following functional support services were not visible:

A. Protection of the prioritised sectors at the start-up level coupled with systematic gradual exposure to international competition;
B. Consistent monitoring of the technological innovation progress from idea to at least first product;

C. The performance management system tracking the ability of the innovative products/services to meet the professional portfolio standards/norms;
D. Government technology innovation/commercialisation support programme(s) based upon the identified “real market need” and the development support of the “necessary” products to address that need; and
E. The state refunding and legal protection of any successful technological innovation with potentially vibrant commercial success.

Because these aspects are not part of the research study but pertinent to it, they will be explicitly raised in chapter 6 as part of the Recommendations.

4.4 Concluding Remarks

This chapter has presented the data and outlined the findings in keeping with the Problem Statement and Research Methodology and Approach, as well as the Research Proposal. While these data and findings were structurally presented along the lines of the performance indicators; they were not critically interpreted nor were conclusions drawn. They have, however, contributed to laying a foundation for this exercise in the next chapter. It seems clear that The Innovation Hub has impacted positively on technology capability of the (start-up) enterprises, though on a limited scale.

CHAPTER 5
ANALYTICAL INTERPRETATION AND CONCLUSIONS

5.1 Introduction

The previous chapter has detailed both qualitative and quantitative data including the findings on the "impact of policy on technology capability" with special reference to the (start-up) enterprises in The Innovation Hub. Because the presentation of the findings was done within the context, and in light of, the literature review; the analytical interpretation thereof will be done in view of the findings and propositions made in chapter 3. This chapter critically interprets and draws conclusions guided by the findings outlined in the previous chapter. This will nonetheless be complemented by additional literature to justify the interpretations and conclusions.

5.2 Critical Examination of the Findings and Propositions[1]

Proposition 1: the enterprises acquired positive business change as a result of their involvement in the Maxum Incubation in The Innovation Hub.

A close scrutiny of the technological level of the 5 enterprises in the "market development", their technological level reflects a time-lag relationship between the original technology priorities and their desired and accomplished technological or commercial outcome(s). In short, the form of positive business change or accomplished technological and commercial goals reflects the "impact" made by The Innovation Hub on the technology capability of the start-ups, confirmed by the fact that 4 (80%) of these enterprises achieved this while still in The Innovation Hub. That 1 (20%) of these enterprises achieved this without the support of The Innovation Hub should not downplay its role. Although a comparison of this nature would have been more helpful in the event of equal representation, it is nonetheless correct to conclude that the start-up enterprises acquired a positive business change as a result of their involvement with the Hub.

[1] For purposes of the study, the terms 'propositions' and 'findings' may be used interchangeably. This is also done in Chapters 3 (3.3.4) and 4 (4.2).

Proposition 2: where government creates an enabling environment, the (start-up) enterprises generally innovate and/or commercialise technology.

Regarding statistical data, government has created the policy environment which is generally conducive for the start-up enterprises to innovate and/or commercialise technology. The Innovation Hub and in particular its core business activities support this. Qualitatively, in assessing the policy aspects that promote technology innovation and lead to attainment of technology capability, that is, the effectiveness of policy, there are aspects that both hamper and/or facilitate attainment of technology capability. In the main, funding constraints and preference for black innovative entrepreneurs over white counterparts compromise the policy objective of economic turnaround. Despite these factors which compromise the potential impact, The Innovation Hub as both a policy implementation programme and its policy implementation aspects has still managed to enable the enterprises to innovate and commercialise their technology.

Proposition 3: the Maxum Incubation effectively provides the necessary support for building the technology capability of the (start-up) enterprises.

Based on the objective of the majority of the enterprises for coming to The Innovation Hub and rated level of performance of the Maxum Incubation; it can be concluded that indeed the Maxum incubation effectively provided the necessary support for building the technology capability of the (start-up) enterprises. The level of performance of the Maxum incubation is considered "effective" in the same variable or functional area predominantly selected as the objective for coming to The Innovation Hub. As The Innovation Hub is in the final analysis a policy implementation programme, its effectiveness in implementing the policy and providing the required support for the start-up enterprises to attain the technology capability i.e. the efficacy of the Maxum incubation, has confirmed the pertinent proposition in this regard.

Proposition 4: if well managed, the technology capability factors contribute to attainment of technology capability.

Clearly, this is one area in which The Innovation Hub has not done well. Statistically, this is far less rated than all other areas as already shown (section 4.2.1-5). Qualitatively, it could be argued that, in terms of R & D, research initiatives of the (start-up) enterprises are delayed due to lack of R & D funding, and consequently, competition takes over. This is exacerbated by the fact that the ICT environment

generally changes very quickly and its products are characterised by a short life cycle. Simply put, R & D does not fulfil one part of the knowledge infrastructure in terms of which:

- knowledge can be expressed and stimulated;
- assist to stay abreast of technological changes; and consequently
- decide on the most relevant knowledge to absorb and adapt.

Similarly, the extent of business collaboration with, or investment by, foreign companies was poor. As marketing is one of the key activities of The Innovation Hub; in respect of FDIs, The Innovation Hub fails in:

- Adapting international best practice to local conditions in response to local market realities; and
- Most significantly, adapting the developed concepts into products and/or commercialising the scientific or academic findings.

Therefore, it could be strongly argued that the importance of each, and/or a combination of the three factors in ensuring that the (start-up) enterprises obtain competitive technology capability is minimal. Consequently, because the enterprises managed to a considerable degree without these factors, it is not always true that, if well managed, the technology capability factors equally contribute to attainment of technology capability. This conclusion is congruent with the FDIs opponents who state that the bulk of FDIs are found more amongst the developed, as opposed to developing, countries.

This conclusion is affirmed by the fact that the majority of the entrepreneurs were academically skilled and had expected to be entrepreneurially equipped by The Innovation Hub. Some of the entrepreneurs complained about the non-business experience of the senior management of The Innovation Hub. The failure to have entrepreneurial technological trajectories emanated from a lack of quality entrepreneurial knowledge infrastructure that facilitates the rate of absorption of both the existing stock of entrepreneurial knowledge and additions to it in order to:

- Consciously structure the operation of the market;
- Shift the basic equilibrium within which the market operates; and/or

- Change the incentive structure for the acquisition of appropriate skills.

Proposition 5: the enterprises commercialised their technologically based solutions as a result of their involvement in The Innovation Hub.
Indeed, the start-up enterprises managed to commercialise their innovations, thus reflecting some technology capability. This is in accord with the objective of turning an already developed technical idea and/or product/service into commercialisation.

Furthermore, the fact that most enterprises came to The Innovation Hub partly due to "affordable office space" and later found that same space relatively expensive should not be misconstrued. The "affordable office space" is one of the enabling conditions for the enterprises to become technologically capable. If the office space was indeed expensive, then the other enterprises could have left The Innovation Hub as well. To be specific, the enterprises which found the office space expensive are mainly those which were renting the less developed office space in the CSIR premises.

5.3 Conclusions

This section outlines the conclusions of this research study, which at one level are based on literature review in chapter 2, which focused on various theoretical perspectives on technology capability. The data/information and the findings made in the previous chapter informed these conclusions to a large extent. In order to ensure that they are scientific, the interpretation and analysis of the findings were on another level critical in arriving at the conclusions. In particular, the critical examination of the propositions and the evaluation of the findings were significant when drawing these conclusions.

The notion by Adams (1997) that technology capability building should result in a clear shift from low-end S & T applications to more sophisticated S & T applications appears to bea practical explanation of the developments taking place in The Innovation Hub. The technological development of educative virtual reality represents a process of turning a novel technical idea into a commercially viable product. Furthermore, the development of the systems that adaptively converge the Internet and GSM networks is in practice a mixture of "turning an already developed technical idea

into a novel use" and "turning a novel technical idea to a familiar use". These technological facets posit the continuously upgraded capacity and ability to provide technologically based solutions. It may be deduced that the start-ups must have acquired some unique value-adding knowledge in keeping with the market changes and needs when providing novelty in either idea, product and use, as these are the underlying requirements for technology capability.

Nonetheless, the technology innovations of the start-ups are predominantly "incremental" and far from being "revolutionary", as defined by Miles (1994). Indeed, the innovations concentrated on small modifications of products that, in most instances, did not require work reorganisation. However, these incremental innovations are in the long run cumulatively significant and possibly "radical", as argued by Miyazaki (1995, p. 28). Though not yet the case with reference to the start-ups, accumulated incremental changes over a long period can be difficult to distinguish from, but are practically equivalent to, a radical change.

The technology innovations made by some start-ups are presumably straddling the lines of distinction between product and process (both technological and organisational). To cite but two examples, the products "Cell Power" and "Cell-ID" appear in two "incarnations", as conceptually asserted by Edquist et al. (1998, p. 31). In the economic system, these are the product innovations, but they are equally the process technologies when used as the prepaid electricity vending system that uses GSM mobile telephones as point-of-sale devices and an authentication system that uses mobile telephones as authentication tokens when logging into computer systems respectively. If indeed product innovations are primarily the most important engine of structural economic change, and process innovations normally have the net effect of efficiency and effectiveness; it is reasonable to conclude that either The Innovation Hub has made an "impact" in this regard or the start-ups have improved their net effect of efficiency and effectiveness.

While the observations made thus far partly demonstrate the "impact" made on the technology capability of the (start-up) enterprises and the indicators against which technological progress is evaluated; they do not account for the extent to which the existing policies created the environment conducive for enhancement of innovation

and diffusion, and the importance of technology capability factors in contributing to technology capability. In view of the data presented and the findings made earlier, it is tempting to conclude that FDIs have played a minimal role, if any, in driving technology development in the case of The Innovation Hub and the (start-up) enterprises. In the cases where there have been collaborations/partnerships with international companies, the start-ups either had to distribute the international company's products (as was the case with the Spescom Data Voice's range of computer-based digital recording equipment) or had to responsively develop technically novel products/services based on the identified (new) market needs, opportunities and commercial exploitation thereof. Therefore, Loveridge's (2002) point on the significance of the TNCs in creating the necessary S & T knowledge, based on their unique internal capabilities, is debatable, although his point on "a variable-sum game", where there is a mutual benefit from international collaboration/partnerships appear to be reasonable.

In view of the discrepancies between the theories in favour of the FDIs and the practical reality of the situation in The Innovation Hub, it follows that, similarly, there were no benefits inherently derived from R & D activities jointly undertaken with the international companies. R & D as the impetus to generate S & T knowledge was further compromised by the lack of forthcoming (domestic) seed funding or venture capital, as some enterprises had written prototypes but did not have the funds to translate them into products. On one level, this experience leads to a conclusion that the start-ups relied heavily relied on their "strategic assets" that constitute the "core competencies" of their enterprises, but not the attractiveness of any external source of expertise over their internal resources. On another level, this experience leads to the conclusion that The Innovation Hub partly failed on a policy level in stimulating these factors for creation of an enabling environment in which technology innovation and diffusion can take place.

Following the effective utilisation of The Innovation Hub as a brand by some enterprises, it could also conclusively be argued that it partly succeeded in stimulating S & T generation and application through social networks like government awareness and promotion campaigns. In particular, the (start-up) enterprises' success could

equally be attributed to policy aspects such as “affordable office space”. In short, The Hub effected the rate and direction of technology capability building.

The building of technology capability is dependent on the quality of the knowledge infrastructure and the degree and the rate of absorption of both the existing stock of knowledge and additions to it. In spite of the complaints about the lack of fully fledged entrepreneur development programmes, it could be concluded that The Innovation Hub contributed to an extent to entrepreneurial development especially through the Networking that makes access to other like-minded people easy. Undoubtedly, the enterprises’ success was equally explicable in terms of the academic qualifications and experience the entrepreneurs had.

As both the literature and the findings have clearly demonstrated, the enterprises’ technology capability depends on a range of factors; and it is proper to highlight the fact that the generated and applied knowledge was almost exclusively domestic/local. In view of this fact, it is appropriate to conclude that the innovated and commercialised products/services were “indigenous”. This should serve as a point of motivation for the promotion and nurturing of the indigenous technologies in The Innovation Hub.

The empirical evidence, supported by the aforementioned conclusions, has revealed some element of incongruence between policy and policy implementation. For example, Dobson’s (2002, p. 244-5) definition of policy clearly encapsulates the idea of systematic “application of knowledge and reason” and strategic allocation and management of resources towards attaining “specific goals”. In spite of the availability of various government (both financial and non-financial) support schemes, most (start-up) enterprises could not develop and ultimately commercialise their prototypes. To reiterate the case in point, the SPII is focussed specifically on the phase that begins at the conclusion of basic research (at the stage of proof of concept) and ends at the point where a pre-production prototype has been produced. This highlights the extent to which The Innovation Hub has failed in fulfilling one of the major underlying capacities of policy management, namely, co-ordination capacity, which refers to co-ordination across all relevant stakeholders/sectors to achieve a common goal (namely, competitive technology capability) and avoidance of duplications, overlaps, wastage of resources and gaps.

5.4 Concluding Remarks

The findings made in respect of this research study have generally reflected some level of "impact" on technology capability made by The Innovation Hub in Gauteng. However, that "impact" can be attributed to a broad spectrum of innovation constituencies including the entrepreneurs' prior (business and academic) experience. In other words, there is a thin line between what The Innovation Hub contributed directly or indirectly, on one hand, and, on the other, the influence of other factors. Nonetheless, it became obvious that entrepreneurial shrewdness enabled some enterprises to use the brand of "innovation hub" to develop business. It is equally true that "affordable office space" was a contributing factor to profit-making.

Based on some issues raised by the (start-up) enterprises, the next chapter makes some recommendations that will most probably consolidate the "impact" on technology capability through The Innovation Hub. The recommendations seek to shift the focus of The Innovation Hub towards a fundamentally transformed business-orientated culture.

CHAPTER 6
RECOMMENDATIONS

6.1 Introduction

This report has attempted to examine the necessary aspects that constitute "impact" on technology capability of the (start-up) enterprises in The Innovation Hub. Some "impact" attributes have been closely linked with The Innovation Hub; those attributes generally linked with The Hub include the effects of networking or usage of the "innovation hub" as a brand as well as the effects of the incubation programme activities like discounted services.

However, based on the goals that were not reached, such as international competitiveness and substantial lack of R & D activities, the enterprises' inputs gave an idea of what needs to be done in order to improve the "efficacy" of The Innovation Hub. Following such inputs and the interpretation thereof, recommendations have been formulated, which are highlighted below, partly in fulfillment of the purpose of this study, namely:

- To demonstrate the extent to which policy can be relevant in creating an enabling environment within which technology capability can be enhanced for global competitiveness; and
- To disseminate knowledge of the innovation concept and trigger debates around its effectiveness.

6.2 Recommendations

The recommendations made in this study are not exhaustive but are simply illustrative of what needs to happen in order to maximise the "impact" of policy on technology capability. Based on the current developments and government support programmes, the recommendations suggest how to optimise their "impact" on the (start-up) enterprises.

6.2.1 The Global Resource Impact Evaluation

There is a need to critically re-examine the unique value-adding role of The Innovation Hub in building technology capability of the (start-up) enterprises. As a point of departure, a comprehensive performance M & E system with clearly defined performance measures/indicators, outputs and outcomes must be developed as a matter of urgency. All performance reports including early warning briefings should be done based on this system. Furthermore, as part of the M & E system, there should be periodic evaluation of the outcomes or impact of The Hub. On one level, the evaluation should focus on business growth and sustainability of the (start-up) enterprises as part of policy performance management. On the other, their business growth and sustainability should be critically evaluated against the enterprises' turnover. Finally, the outcomes of this dual evaluation should consider the global resource/input invested by The Innovation Hub. This approach will be in line with period evaluation done by Malaysia, a country on almost the same level of development as South Africa.

The proposed performance management system would bridge most of the current gaps. To cite but one general gap, the "impact" claimed by The Innovation Hub and by this study thus far has been output and medium-term outcome orientated. The deficit of this approach is clearly seen in the difficulty in categorically distinguishing the unique value-adding factors contributing to the technology capability and exclusively derived from The Innovation Hub. For example, the (start-up) enterprise that was not part of The Innovation Hub could competitively provide technologically based solutions and/or support long-term sustainable development which give(s) it an economic and commercial edge over those which were part of The Innovation Hub.

6.2.2 The Business Cluster Formation

One of the proposed performance indicators identified by the (start-up) enterprises themselves is regular consumption/application of their innovative products/services by the target consumer group. If this proposal were to take cognisance of the market

realities, then the challenge would inevitably be that this is undoubtedly an era of niche markets in which customers have become accustomed to high quality and extensive choice. Therefore, the challenge of each (newly started) firm is inevitably to slot into a genuinely new niche market if it wants to remain competitive. However, the competitors themselves also develop strategies which give them flexibility to move into a controlling position at various stages of the race. An interplay of these dimensions make the customer choice wider and the market characterized by unavoidable fierce competition for both clients and suppliers.

An interplay of these dimensions constitutes the market reality, and the strategic market entry for start-up enterprises could therefore possibly be to provide business services in support of one another. The Innovation Hub as a science park should provide support services that foster cluster group formation especially in view of the costly and tedious process of technology innovation. The institutionalised provision of such services is in line with certain policy directions. NRDS (2002, p. 31) clearly asserts that often successful missions are "captured" by particular clusters that become global players. The examples of successful enterprises that started with a government-supported venture capital scheme are Nokia in Finland, Intel in the United States, SASOL in South Africa, and the jewellery and fashion clusters in Italy. The implementation of this recommendation would not require any structural or functional rearrangements since all the start-ups in The Hub are in the same (ICT) sector.

6.2.3 The Industry/Sector Specialisation

The idea of business cluster formation recommended in 6.2.2 presupposes that the (specialised) science parks are established. The Innovation Hub could easily be turned into one as of now only ICT start-up enterprises are under its various programmes. Such policy direction would demand that, in promoting and inculcating the culture of clustering amongst the start-up enterprises, any science park should essentially balance the self-serving nature of business with co-operation. Furthermore, one of the challenges in this regard is to keep in mind that there is no 'one-size-fits-all' policy. In other words, the start-up enterprises may form cluster type organisations based on mutual interest determined by the company size, geographical location, problem definition or some other identifiable characteristic. Government technology

innovation/commercialisation support programme(s) should be based on the identified "real market need" and the development support of the "necessary" products to address that need.

Some of the expected benefits of this proposed policy direction:

A. Co-operation between start-up enterprises may be an important way of increasing individual capabilities as it can provide complementary resources, such as technology and information exchange, management assistance, etc., in areas where they have complementary interests but cannot act efficiently alone;
B. The start-up enterprises in a business cluster may also collectively achieve economies of scale; and
C. The ability to leverage resources to adapt to changes in the markets and to fluctuations in technology may be increased.

The expected valuable advantage would obviously be to solve specific technological needs as government has to designate particular technological innovation areas for each science park.

6.2.4 Promotion of Indigenous Technologies

Although the technology capability may often be developed initially by borrowing foreign technologies, as it may appear to be the endeavour or wish of the start-ups; the attainment and sustainability of the technology capability has to depend on indigenous technologies. NRDS (2002, p. 45) maintains that the collective inherited and evolving knowledge systems of indigenous communities constitute scientific areas where there is an obvious knowledge advantage. Without the indigenous technologies, the proposed business cluster may only be an enclave at best.

Therefore, the government has to make sure that indigenous technologies can be accumulated along with the formation of an industrial cluster. In order to accomplish this goal, some of the possible policy pathways are:

A. Protection of the prioritised domestic economic sectors at the start-up level coupled with systematic gradual exposure to, and for competitive participation in, international competing economic activities;

B. Consistent monitoring of the technological innovation progress from idea to at least first product; and
C. The state refunding and legal protection for any successful domestic technological innovation with potentially vibrant commercial success.

6.2.5 Enhancement of Legal Support Services

IPRs have emerged internationally as key tools for managing innovation and resolving some of the "market failures" faced by innovating (start-up) enterprises. Generally, to give but one example, the difficulty for the small enterprises in doing business with the big companies is experienced when turning the "written prototypes" into full products as raised by the enterprise that left The Innovation Hub prematurely. In order to adopt a policy that will impact positively on technology capability of the (start-up) enterprises, enhancement of their awareness and knowledge of all elements of the intellectual property system is necessary. The most indispensable pillars for technology innovation, commercialisation and ultimately capability include patents, trademarks, industrial designs, trade secrets, copyright and related rights.

Therefore, the (start-up) enterprises involved in technology innovations should be provided with these services by the respective science parks. This should include support for application and for the resolution of intellectual property disputes as these are found to be complex and costly for the start-ups. This recommendation is in keeping with the NRDS (2002, p. 16) that: "We need to develop competencies as a matter of urgency or face exploitation and marginalisation with respect to our own resources".

6.2.6 Institutionalised S & T Linkages

Co-ordinated integration and implementation of the government-sponsored/run programmes was highlighted throughout this study as a major challenge. This challenge is exacerbated by a lack of clear M & E systems for technological progress in The Innovation Hub. The remedy for meaningful "impact" does not lie simply in rolling out a co-ordinated integration and implementation of programmes coupled with

M & E system. The critical component of such an initiative is a system of peer review, with a common exploration of issues through conferences and seminars and exchange of scientists through post-doctoral research fellowships and sabbaticals which could serve as a basis for meaningful "impact" on technology capability of the start-ups. Therefore, it should be mandatory that all government sponsored/managed scientific programmes be subjected to provincial review, before national review.

6.3 Concluding remarks

In conclusion, it is appropriate to highlight Miyazaki's (1995, p. 19) point: If an enterprise is unable to sustain technology capability, it will fail to keep up with the technology race. Its products will tend to lose competitiveness, even if it has other areas of competencies, such as financial and marketing competencies. It is the view of the author that if these recommendations were to be implemented, then The Innovation Hub will in consequence serve as the point of intersection between ideas and action, between research and development, between innovation and entrepreneurship with the aim of:

- Unlocking the country's economic potential in chosen areas particularly economic renewal in Gauteng;
- Proactively stimulating high-technology business growth and development of the required skill base; and
- Striving to attract and stimulate venture capital as asserted by the Annual Report (2002/03, p. 15).

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ANNEXURE A

INTERVIEW QUESTIONS

1. THE (START-UP) ENTERPRISE TECHNOLOGY STATUS

1.1. When your enterprise came to the Maxum Incubation Programme, the objective was to:

a. Turn a novel technical idea into novel product/service;
b. Move a technical idea through to its commercialization;
c. Turn an already developed technical idea into novel product/service;
d. Move an already developed technical idea and/or product/service into commercialization; or
e. Turn a novel technical idea to a familiar use?

1.2. What are the main technology innovation areas for your enterprise?

1.3. What are the key performance indicators to measure your technological progress and/or capability?

1.4. Rate the technological progress made during your enterprise's involvement in The Innovation Hub in relation to the following:

1.5.

a. The product/service innovations

Please tick appropriate box							
NE		LE		E		VE	

b. Process technology innovations

Please tick appropriate box							
NE		LE		E		VE	

c. Organisational innovations

Please tick appropriate box							
NE		LE		E		VE	

d. Work reorganisation

Please tick appropriate box							
NE		LE		E		VE	

e. Productivity

Please tick appropriate box							
NE		LE		E		VE	

Explain:

2. THE POLICY ENVIRONMENT

2.1. What would you regard as the conducive policy environment for technology innovation and/or commercialization?

2.2. To what extent would you say the government policies have created an environment that enabled your enterprise to innovate and/or commercialize its technology? Why?

Please tick appropriate box							
NE		LE		E		VE	

Explain:

2.3. What are the policy aspects that enabled your enterprise to innovate and/or commercialise its technology?

2.4. What are the policy aspects that need to be improved or changed in order to better help the (start-up) enterprise build technology capability?

3. THE MAXUM INCUBATION AS A TECHNOLOGY CAPABILITY BUILDING AGENCY

3.1. To what extent would you say the Maxum Incubator as a programme in The Innovation Hub has succeeded in facilitating technology innovation and/or capability building? Why?

Please tick appropriate box							
NE		LE		E		VE	

Explain:

3.2. What are the incubator aspects that enabled your enterprise to innovate and/or commercialize your technology initiatives?

3.3. What are the incubator aspects that need to be improved or changed in order to better help the (start-up) enterprises build technology capability?

3.4. Based upon your experience when dealing with the Maxum Incubator in The Innovation Hub, please indicate its level of performance in relation to the following activities:

a. Turning a novel technical idea into novel product/service

Please tick appropriate box							
NE		LE		E		VE	

b. Moving a technical idea through to its commercialization

Please tick appropriate box							
NE		LE		E		VE	

c. Turning an already developed technical idea into novel product/service

Please tick appropriate box							
NE		LE		E		VE	

d. Moving an already developed technical idea into commercialization;

Please tick appropriate box							
NE		LE		E		VE	

e. Turning a novel technical idea to a familiar use;

Please tick appropriate box							
NE		LE		E		VE	

Explain:

4. THE IMPORTANCE OF THE TECHNOLOGY CAPABILITY FACTORS

4.1. To what extent has the Maxum Incubator in The Innovation Hub stimulated and harnessed the flow of the SET knowledge amongst the academic and R & D institutions, markets and (start-up) enterprises?

4.2. How important has each of the following technology capability factors been in contributing to your enterprises's technology innovations and/or capability?

a. FDIs;
b. R & D;
c. HCD, particularly entrepreneurial SET knowledge;
d. Integration of the three factors by The Innovation Hub?

4.3. What is your general comment and/or impression on any, or all, of the four factors in terms of effectiveness in transferring the entrepreneurial SET knowledge?

5. IMPACT EVALUATION

5.1. What are the main reasons for failing to commercialize some of the main technology innovations?

5.2. What are the main reasons for succeeding in commercializing some of the main technology innovations?

5.3. Are you planning to venture into any technology innovation initiatives in the near future? Why?

5.4. Is there anything you would like to comment on or add in relation to technology capability building for the (start-up) enterprises?

ANNEXURE B.

RESEARCH POPULATION

B1. Enterprises in the Incubation Programme

1. Active Touch (Pty) Ltd
2. Automated Product Development (APD)
3. DBIT Management Systems
4. SRM Technologies (Pty) Ltd
5. TCI-Thoreb (Pty) Ltd
6. Techsolutions (Pty) Ltd
7. TMI Consulting

B2. Market Development Enterprises

1. Electrosoft
2. Expertron
3. Mohwiti Technologies (Pty) Ltd
4. Naledi3D Factory
5. Spline Technologies