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# Competitiveness of South Africa's biotechnology sector


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# ABSTRACT

In 2001, the South African government developed a biotechnology strategy and set aside approximately $70 million to support and stimulate the development of biotechnology skills, capabilities and tools in South Africa(Campbell, 2007). During the past seven years, since the strategy's inception, no independent qualitative analysis has been conducted, which could provide insights into its strengths, weaknesses and the views of the different stakeholders within the industry as to the degree of stimulation and competitiveness the strategy as achieved.

Competitiveness at a nation level is best described using Porter's Diamond of National Competitiveness model which provides a framework for analysing competitiveness at an industry level. This analysis was performed by carrying out qualitative interviews with relevant stakeholders in the industry (government, the private sector, universities, science councils and venture capitalists) and assessing the sector in terms of the four attributes of the Diamond model.

The findings show South Africa's nascent biotechnology industry is stumbling at every step of the value chain, from laboratory bench to factory gate. A handful of first-class scientists vie for limited government funding, few of them have the expertise to commercialise their ideas, and domestic private capital has yet to be convinced that there is money to be made in the sector. Some of the key shortages are an entrepreneurial spirit in the research community and the lack of concentration of knowledge workers. There is a shortage of funding for sustaining new business projects created in medium and long-term research and development programmes with cooperation between scientists and entrepreneurs still at embryonic levels.

# DECLARATION

I declare that this research project is my own work. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration at the Gordon Institute of Business Science, University of Pretoria. It has not been submitted before for any degree or examination in any other University.

SIGNED:______________________ ______________________

NIVAN MOODLEY DATE

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# CONTENTS

# LIST OF FIGURES

# LIST OF TABLES

# Chapter 1 Problem Definition

This chapter elucidates the importance of the research and research objectives, scope and motivation and the pertinence of the research.

## 1.1 Introduction

Biotechnology is internationally recognised as the next revolutionary scientific endeavour in the history of humankind. Researchers suggest that in the same way that steam power and the railway, and more recently, information and communication technologies have revolutionised society, biotechnology will change the way we live and think about living organisms and society (Freeman and Soete, 1997).

For many years, government officials and economists in many countries have concentrated on technological innovation as a means of economic growth (Kong, 2001). Life sciences and biotechnology are widely recognised to be, after information technology, the next wave of the knowledge-based economy, creating new opportunities for our society and economics. Biotechnology is recognised as one of these key technologies that will shape medicine in the 21st century (Akermann and Kermani, 2006).

Over the past few years there has been an explosion of interest in biotechnology in South Africa. Politicians and policy makers have become increasingly interested in the role of biotechnology in economic growth. Policy initiatives in South Africa in support of biotechnology resulted in a National Biotechnology Strategy in 2001. Government has identified biotechnology as a means of promoting the achievement of national priorities such as improved health care, food security, job creation and environmental protection.

> In his *State of the Nation Address in Cape Town* on 9 February 2001, Thabo Mbeki stated: "We recognise the fact that competitiveness is driven by technological advances and innovation. In recognition of this, investment in research and development is one of the focal points of our integrated plan aimed at attaining a cutting edge in key areas such as biotechnology."

The South African government has set aside approximately $70 million to support and stimulate the development of biotechnology skills, capabilities and tools in South Africa (Campbell, 2007). However, the strategy was formed in the context of a paucity of qualitative and quantitative data regarding R&D in biotechnology in South Africa. This strategy is, at present, in the process of being reviewed and re-evaluated. During the past seven years, since the strategy's inception, an independent qualitative analysis has not been conducted, which could provide insights into its strengths, weakness and the view of the different stakeholders within the industry as to the degree of stimulation and competitiveness the strategy has achieved.

## 1.2 Definition and relevance of biotechnology

The South African National Biotechnology strategy (2001) defines biotechnology as a "set of technologies including, but not confined to, tissue culture and recombinant DNA techniques, bioinformatics and genomics, proteomics and structural biology, and all other techniques employed for the genetic modification of living organisms used to exploit and modify living organisms so as to produce new intellectual property, tools, goods, products and services". This definition is specifically focused on third generation biotechnology, therefore the focus of this study is third generation biotechnology (for a definition, see Section 2.2).

The success of any knowledge-based economy rests upon the generation, diffusion and application of new knowledge (Cloete, 2003). Biotechnology is a knowledge-intensive sector and two of the major drives of growth are R&D innovation. In the USA alone, for example, private sector investment in biotechnology R&D in 2006 amounted to over $14.2 billion (Gastrow, 2008). Governments also support biotechnology R&D. The Korean government spent $727 million (PPP adjusted) on public-funded R&D in 2003. Investments in research development, education and training and new managerial approaches are therefore of key importance in meeting the challenges posed by life sciences and biotechnology (Cloete, 2003). The South African government has established several Biotechnology Regional Innovation Centres (BRICs) and has put initiatives in place to encourage partnerships that could potentially encourage internal development of biotechnology. The key elements of successful biotechnology industries include a clear vision of and focus on knowledge generation, application, translation and dissemination as a core competitive advantage. Important elements of this knowledge base include the ability to achieve successful multidisciplinary/technology integration to proactively capture 'white space' opportunities. Networking and value chain-based partnerships and collaboration are hallmarks of successful organisations in this field.

Biotechnology is a *cross-cutting* technology. It is subject to wide application across sectors and biological boundaries. The potential for applications of life sciences and biotechnology promises to be a growing source of wealth creation in the future, leading to the creation of jobs, many of which will be highly skilled, and new opportunities for investment in further research (Cloete, 2003). The management of economic production can be organised in such a way as to benefit from this 'cross-fertilisation' feature of biotechnology.

## 1.3 Scope of the research

The scope of the research is described by the definitions of the following relevant terms:

- The scope of the evaluation will focus on activities funded by the South African Government since 2001 to execute the National Biotechnology Strategy.

- Biotechnology sector definition will include people who have been involved in the third generation biotechnology industry for at least five years and who have occupied senior management and senior scientist positions.

  - Senior Management is defined as people who have held significant leadership roles in their organisations, have controlled day-to-day operations and who have decision-making powers.

  - Senior scientists are defined as people who have been principal investigators in projects valued at over R3 million funded by the biotechnology strategy.

The research will not:

- Assess companies involved in 1st and 2nd generation biotechnology activities.

- Ascertain any financial performance figures or trends.

- Be a case report on the biotechnology cluster in South Africa.

- Be a comprehensive survey of the biotechnology industry in South Africa.

## 1.4 Research motivation

The rationale behind this motivation is pertinent to the present situation in the biotechnology sector. The need for such data is apparent within the biotechnology industry, where discourse with respect to R&D is vibrant but lacking in reliable data to support this theory. The Bio2Biz conferences bring the different stakeholders in the biotechnology industry together, and at the 2007 conference, debates on the direction that should be taken to support a sustainable biotechnology sector were strong. However, one element missing from these debates was concrete evidence on the state of affairs of the biotechnology sector. From a personal perspective, the purpose of this research is to give a voice to the scientists who appear to be directly affected by the strategy and the changes to be implemented in the next eighteen months.

## 1.5 Research problem

Up to the present there has been no specific means of measuring and assessing the effectiveness and success of the BRIC system. To date the South African government has little to show for the R450 m expended on the three regional innovation centres. Three studies have been conducted since the adoption of the South African National Biotechnology Strategy. The most recent study conducted by (Donninger, 2006) used Porter’s Diamond of National Competitiveness model and showed that all the attributes of the Diamond model were weak. A second study was conducted by (Motari *et al.*, 2004), and the third was commissioned by the Department of Science and Technology and Egoli Bio Life Sciences Incubator (Mulder and Henschel, 2003). Both studies simply investigated the state of the industry but did not assess the success of the strategy. With an update on the strategy expected in 2008, it appears to be an appropriate time to determine the impact over the last seven years and to explore the attitudes and perceptions of operators and stakeholders in the industry.

This research is a follow-up study on the research study by (Donninger, 2006) with the following aims:

- Assess the biotechnology sector in terms of the four broad attributes of the Diamond of National Competitiveness.

- Assess the strengths and weaknesses in terms of the Diamond model.
- Determine whether the development of a biotechnology cluster is viable in growing the sector.

# Chapter 2 Literature Review

This chapter reviews the desktop study that was undertaken on the topic. It discusses relevant academic literature on the topic, sheds light on the topic and refines and defines the research problems.

## 2.1 Introduction

The literature review and supporting theory base that were used focus on providing a discussion of the biotechnology industry worldwide and highlighting the key success attributes required based on the global success of biotechnology-focused countries. A literature assessment of competitiveness from a country perspective is examined and four different models used to measure competitiveness are summarised. This is followed by a brief discussion of the concept of the development of 'high technology' industries by the establishment of science parks or incubators and innovation centres which are aimed at promoting the development of clusters. Finally, a conclusion section identifies the literature framework to be used.

## 2.2 Introduction to biotechnology

The term biotechnology was coined in 1919 by Karl Ereky, a Hungarian agricultural economist, and referred to all the lines of work by which products are produced from raw materials with the aid of living organisms (Fári and Kralovánszky, 2006). The use of biological agents as a means of making products can be dated back to ancient times when brewing, bread-making and cheese-making were discovered by the Babylonians and Egyptians (Kong, 2001).

Biotechnology is a cross-cutting technology, which supports innovation in health, agriculture, food processing, industry and environmental management (Mulder and Henschel, 2003). It can be simply defined as the application of technology to utilise or modify living organisms for a particular benefit, such as the production of new knowledge, products, processes or services (Mulder and Henschel, 2003).

Biotechnology is typically classified as either first, second or third generation. First generation biotechnology involves the use of wild type or natural biological organisms to produce a product, for example, the use of yeast to make beer or wine (Mulder and Henschel, 2003). Second generation biotechnology refers to the production of specific products using a pure cell or tissue culture of organisms that have been specifically selected, through random cross-breeding or similar techniques, for their superior production or expression abilities without introducing foreign DNA (Mulder and Henschel, 2003). Third generation biotechnology involves manipulation of the genetic make-up of organisms by introducing selected foreign (across the species barrier) DNA, through recombinant DNA technology, to make them produce small molecules, compounds or proteins they would not normally produce (Mulder and Henschel, 2003). More recently, first and second generation biotechnology have been referred to as ‘old biotechnology’ and third generation biotechnology has been referred to as ‘new biotechnology’ or ‘modern biotechnology’ (Figure 1) (Mulder and Henschel, 2003).

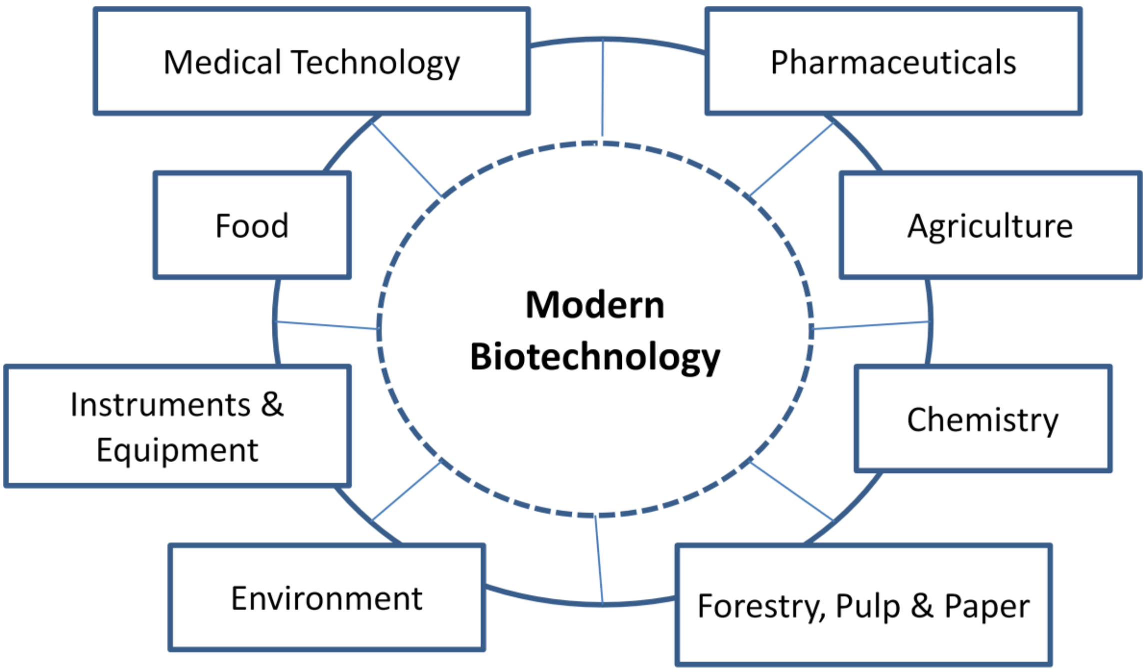


**Figure 1: Sectors involved in modern biotechnology**

## 2.3 The global biotechnology industry

As with many countries around the world, South Africa is keen to develop its biotechnology capabilities. A vibrant biotechnology sector could have economic benefits and could play a useful role in tackling diseases that predominantly affect South Africa but are currently underserved by the R&D efforts of multinational companies (Akermann and Kermani, 2006). The emphasis on biotechnology has been influenced by the outstanding success of the US biotechnology industry. The biotechnology sector has shown rapid growth from 2000 to 2004, with global revenue rising from $22.7 billion to $54.6 billion (Young, 2007). This has been the strongest growth sector in the pharmaceutical market (Young, 2006).

**Figure 2: Biotechnology clusters around the world**

The United States leads the global industry but Europe and the Asia-Pacific region are making efforts to catch up (Young, 2007). Table 1 provides an overview of the global bio-economy. The most successful biotechnology clusters are found in the UK at Cambridge and in the USA at the Bay Area and in Boston (Smith, Coetzee and Mulder, 2005). Biotechnology clusters more comparative to those in South Africa are found in:

- Australia
- Cuba
- Ireland

- Israel
- New Zealand
- Singapore
- South Korea

These clusters are considered to be comparative to those in South Africa because (Smith *et al.*, 2005):

- they also represent smaller and developing economies similar in size with limited resources
- are located far from large markets
- have a proactive biotechnology strategy.

**Table 1: Global biotechnology at a glance in 2006 (Young, 2007)**

| | Global | USA | Europe | Canada | Asia-Pacific |
|---|---|---|---|---|---|
| **Revenues (US$ m)** | 73 478 | 55 458 | 11 489 | 3 242 | 3 289 |
| **Revenues (US$ m)** | 27 782 | 22 865 | 3 631 | 885 | 401 |
| **Net loss (US$ m)** | 5 446 | 3 466 | 1 125 | 524 | 331 |
| **Number of employees** | 190 500 | 139 600 | 39 740 | 7 190 | 12 970 |
| **Number of companies** | | | | | |
| **Public companies** | 710 | 336 | 156 | 82 | 136 |
| **Public and private companies** | 4 275 | 1 452 | 1 621 | 465 | 737 |

## 2.4 Summary of biotechnology success in the US

There is little doubt that the USA has done better than the rest of the world in developing a vibrant and successful biotechnology industry (Table 1). The success of biotechnology in the US was driven by two key elements. There was a strong science push drawing from a well-developed strong research base (Reiss, 2001). Secondly, the technological and commercial potential of this science push was realised rather early by the private sector (Reiss, 2001). Entrepreneurs were willing to take a risk in exploiting biotechnology products for commercial gain and the private investors risked investing private capital in new business.

The USA has more than 300 public biotechnology companies employing approximately 130 000 people, with a market capital of US$400 billion, thus making it a valuable contributor to the national economy of the United States (Mullen, 2007).

## 2.5 Summary of biotechnology success in Europe

During the start-up phase of biotechnology, governments in France, the UK and Germany provided modest funds to stimulate basic research and development. Initially, policy makers focused on stimulation to develop new technologies and promote biotechnology (Zechendorf, 2004). In these time success fell short of expectations and the reason for failures was identified as insufficient transfer of the new technologies and knowledge to the economy (Zechendorf, 2004). These governments implemented the following changes to stimulate the sector (Zechendorf, 2004):

1. Venture capital was non-existent in biotechnology at that time. This was stimulated through the creation of venture capital through seed funding.

2. Bio-incubators were set up to help young companies.

3. Increased technology and cooperation was achieved through the creation of clusters of private companies close to high-level universities and through focusing on overcoming the dichotomy between industry and academia in order to foster technology transfer.

The numbers of publicly traded companies in Europe in 2007 were 181 with a further 1 744 public and private companies (Young, 2007).

## 2.6 Summary of biotechnology success in Cuba

Cuba is a small country but has a vibrant and flourishing biotechnology sector. South Africa has looked at the Cuban model of biotechnology and has tried to create a similar environment locally. Some typical traits of the sector are (Mola, Acevedo, Silva, Tormo, Montero and Herrera, 2003):

- The Cuban government is the major investor.

- Biotechnology is part of the health system.

- Cuba has developed highly skilled scientists and professionals.
- National collaboration instead of individual competition.
- Operates in a 'closed cycle' by fully integrated institutions capable of both scientific and business excellence.

## 2.7 Summary of key findings in developing a biotechnology sector from around the world

There is, of course, no magic wand that can be waved to create successful biotechnology sectors, but industry and policy experiences from other countries can be instructive. Some typical traits of the biotechnology activities from developed and developing countries are (Wolson, 2005):

- A dedicated agency is required to champion biotechnology and coordinate relevant activities to ensure coherence between programmes.
- Strong scientific and technological capabilities must be built, focusing on human resources development, complemented by ensuring access to cutting-edge equipment and information.
- Investment should be focused on the generation of commercial products and processes for both local and international markets.
- The development of dedicated bio-incubators and science parks has stimulated the industry and moved products from the point of academic interest to commercial products.

## 2.8 Barriers to entry in developing a biotechnology sector assessment based on the literature

### 2.8.1 Human resources

Highly specialised skills are required to develop the biotechnology sector with a mixture of both academic and business skills. Currently there is an over-emphasis on basic research as opposed to applied research (Ndhlovu, 2007). Secondly, developing countries are facing losing the skills they have developed to the developed world (Ferrer *et al.*, 2004, Motari *et al.*, 2004, Thorsteinsdottir *et al.*, 2004, Zhenzhen *et al.*, 2004).

### 2.8.2 Capital

Low levels of venture capital and angel funding investment both for early and late stage R&D in health biotechnology are available. There is only one bioventure capital firm which has already spent all its money and will not be funding new projects in the next few years. This, together with low levels of public sector funding creates an imposing barrier for bridging the gap between basic research and commercialisation (Zhenzhen *et al.*, 2004, Motari *et al.*, 2004, Thorsteinsdottir *et al.*, 2004).

### 2.8.3 Regulatory environment

The government has created a biotechnology policy and which can be seen as a positive sign that government sees biotechnology as an important sector for economic growth. However, government policy needs to be more decisive, and development has to be identified as a national priority (Ferrer *et al.*, 2004). To enhance competitiveness and productivity, the regulatory framework and environment need to improve (Ferrer *et al.*, 2004, Thorsteinsdottir *et al.*, 2004).

## 2.9 Biotechnology in South Africa

The recently published 'Ten Year Plan' of the Department of Science and Technology has the vision of South Africa being among the top ten nations in the world in terms of the pharmaceutical, nutraceutical, flavour, fragrance and bio-pesticide industries by 2018 (DST, 2007).

South Africa had established a reputation in the technological processes involved in brewing and agriculture (first and second generation biotechnology), however it has less experience in applying biotechnology to healthcare (third generation biotechnology) (Akermann and Kermani, 2006). In 2000, the South African Government began to focus on and substantially increase its research support for biotechnology (Cloete *et al.*, 2006). This led to the adoption of the National Biotechnology Strategy in 2001, and the government allocated close to R450 million towards its implementation (Young, 2006, Cloete *et al.*, 2006).

The National Biotechnology Strategy addresses human resource development, funding, regulatory and legal issues; it also endeavours to close the gap between research activities and commercialisation which it calls the 'innovation chasm' (Cloete *et al.*, 2006).

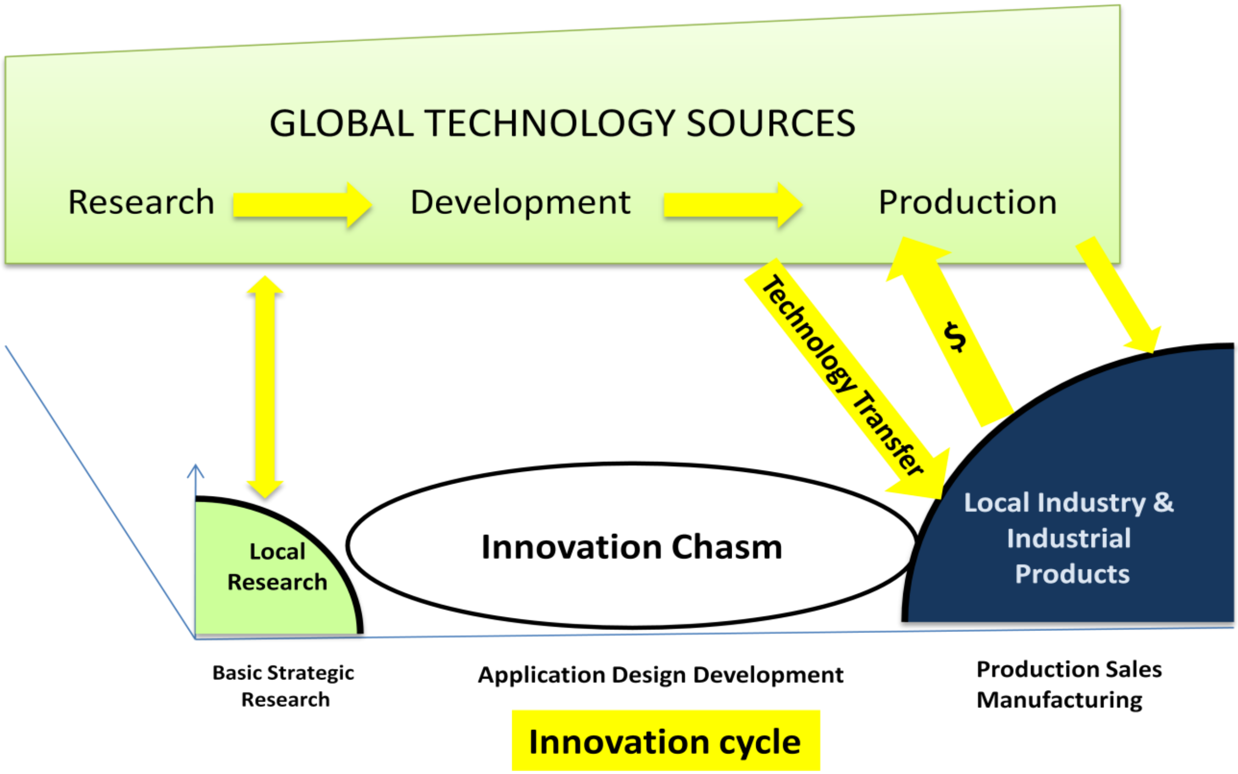


**Figure 3: The innovation chasm highlights the gap between basic research and commercialisation of products**

The 'innovation chasm' prevents productive interactions between knowledge generators and the market. At the upstream end of the innovation value chain, some high-quality basic and strategic research is taking place and at the downstream end, relatively sophisticated manufacturing operations can be found, but these typically employ technology sourced abroad rather than developed locally (Wolson, 2005). Local institutes rarely exploit their technology in the market place. The policy initiatives have been designed to bridge the 'innovation chasm' between research institutions and industry, which exists as consequences of inadequate support and weak linkages between stakeholders (Cloete *et al.*, 2006).

Science and technology have become a pillar of the knowledge-based society and a fundamental catalyst for economic development. Science ultimately supports the innovation and concepts that meet societal needs and drive economies. For many developing countries there are no more important steps toward eradicating poverty than to provide adequate nutrition and to suppress diseases that drain a population's strength, morale and earning ability (Cloete, 2003). The Department of Science and Technology has realised that these challenges are best addressed by people who are well trained in modern biotechnology sciences and who live among the very poor. By training more local scientists in biotechnology, South Africa can create the human resources it needs to confront such biological challenges on its own home ground (Cloete, 2003).

Furthermore, private-public partnerships are encouraged (Cloete *et al.*, 2006). The key enabler of the strategy was the establishment of three regional innovation centres (BioPAD, Lifelab and Cape Biotech) and one national plant biotechnology centre (PlantBio). The four centres aim to promote and support the national biotechnology innovation programme (Pouris, 2007) . The objectives of the innovation centres are to act as centres for the development of biotechnology platforms throughout the country. The platforms in turn act as enablers for the growth of start-up companies. This initiative involves the strategic development of several 'bioclusters' rather than allowing clusters to grow under their own impetus (Cloete *et al.*, 2006). Secondly, it was envisaged that the biotechnology platform would provide a solid research and human capital development agenda for both academics and entrepreneurs (Young, 2006).

According to the National Biotechnology Survey (Mulder and Henschel, 2003) of South Africa's biotechnology industry, there are about 106 biotechnology firms, including 47 identified as 'core' companies - that is, the majority of their activities are in biotechnology. Of the core companies, 37% were spin-offs from another enterprise, 34% were start-ups and 29% were spin-offs from a research group (Mulder and Henschel, 2003). However, very few products from these projects have been commercialised and this was largely put down to the unfocused approach to national biotechnology R&D (Akermann and Kermani, 2006). The strategy adopted in 2001 was meant to be an enabler to overcome the challenges to commercialisation.

## 2.10 Assessing national competitiveness

Global competitiveness and the relationship between technology and competitiveness has been the subject of considerable analysis and discussion. In microeconomics, the term 'competitiveness' refers to the capability of firms to compete in the domestic or global market (Kong, 2001). A wide range of indicators such as market shares, profit and growth, dividends and investment are used to assess the competitiveness of firms.

The evidence presented by Porter (1990a), Romer (1990), IDRC (1993), UNDP (2001) and Lingela and Buys (2007), confirms that the rate of technological progress determines the ability of an industry to open new markets, develop new products and services that command high prices in domestic and international markets. Firms that offer products that are adapted to the needs and wants of target customers and that market them faster and more efficiently than their competitors are in a better position to create a sustainable competitive advantage (Prahalad and Hamel, 1990, Amit and Schoemaker, 1993, Nonaka and Takeuchi, 1995, Calantone *et al.*, 1995). Competitive advantage is increasingly derived from knowledge and technological skills and experience in the creation of new products (Teece, Pisano and Shuen (1997), Tidd, Bessant, Pavitt (1997)) .

## 2.11 World competitiveness model

The world competitiveness report provides a point of reference of how nations manage their economic future. The IMD World Competitiveness Yearbook defines business competitiveness as (Garelli, 2003, p. 702): "*Competitiveness of nations looks at how nations create and maintain an environment which sustains the competitiveness of their enterprises.*"

The competitiveness cube model is used to determine the competitiveness of a nation (Figure 4). There are four dimensions to the cube and each is described below. The model highlights the priority of how a competitive nation should be to developing people who are able to operate the new technological infrastructure and strive to be at the leading edge of future development (Garelli, 2003).

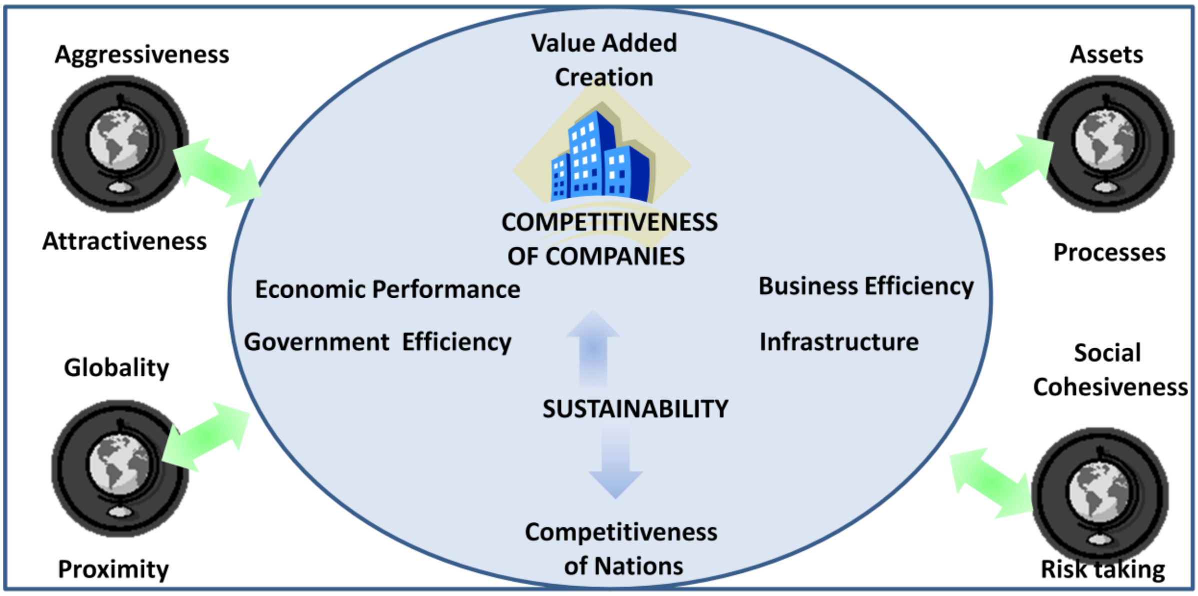


**Figure 4: The Competitiveness Cube (Garelli, 2003)**

### 2.11.1 Attractiveness vs. aggressiveness

This measures the ways that nations manage their relationships with the world business community (Garelli, 2003). Aggressiveness is the way nations interact on the world market and whether they focus on exports and foreign direct investment (FDI) and how these are managed. Attractiveness comprises incentives and job creation, but it can be short on income due to incentives. Companies need to focus on both attributes in order to compete today.

### 2.11.2 Proximity vs. globality

These attributes deals with measures of openness of trade (barriers), trade agreements, regional integration, privatisation and deregulation (Garelli, 2003). The economy of proximity provides value added close to the end user. It is protectionist and expensive, whereas globality looks at operational efficiency.

### 2.11.3 Assets vs. processes

Nations manage their competitive environment by competing more heavily either on assets or on processes (Garelli, 2003). Certain nations are rich in assets – land, people, natural resources - but are not necessarily competitive. Countries with poor resources tend to focus on transformation processes (Garelli, 2003).

### 2.11.4 Individual risk taking vs. social cohesiveness

The fourth force shaping the competitiveness environment of a country is the distinction between a system that promotes individual risk and one that preserves social cohesiveness (Garelli, 2003).

In order to assess the competitiveness of the sector, three models were analysed from the literature:

- Porter's Diamond Model
- Innovation and Management Framework
- National Innovation System

## 2.12 Porter's Diamond Competitiveness Model

Porter (1990a) in his seminal work indicated that the competitiveness of a firm depends not only on its competitive strength or core competence micro-economically, but also on the interaction of its capabilities with its external environment. In 1990 Porter developed a model called the 'Diamond of National Competitiveness'. The diamond shows the relationship between four sets of factors or attributes which together influence the success of a nation's firms (Figure 5) (Porter, 1990a, Porter, 1990b).

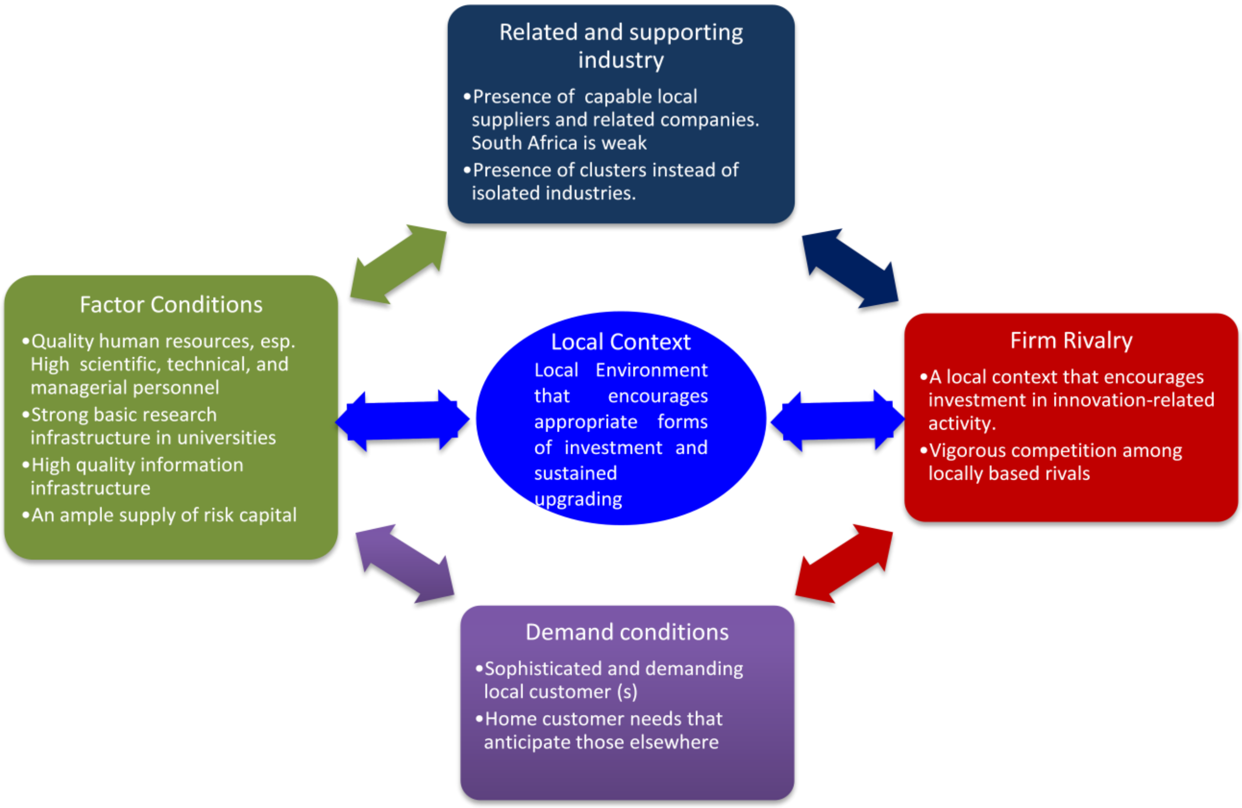


**Figure 5: Porters Diamond Competitiveness Model**

### 2.12.1 Factor conditions

According to Porter's Diamond Model, factors of production are the basic sources of competition. Factors are (Porter, 1990a, Porter, 1990b):

- *Human resources:* skilled labour pool and cost of personnel.
- *Infrastructure*: the type, quality and user costs of infrastructure available that affects the competition. Infrastructure also includes aspects that affect the quality of life and attractiveness of a nation as a place to live and work.
- *Capital resources:* the amount and cost of capital available to finance the industry and raw material required to compete in a given industry.
- *Knowledge resources:* the nation's stock of scientific, technical and market knowledge.

The South African surveys by (Donninger, 2006) and (Mulder and Henschel, 2003) identified skills shortages. Porter (1990a, p. 80) states that "to support competitive advantage, a factor must be highly specialised to an industry's particular needs".

### 2.12.2 Demand conditions

Porter (1990a) states that home demand conditions for the industry's product or service are critical to competition and success. Three broad attributes are described as being significant (Porter, 1990a, Porter, 1990b):

- The composition of home demand buyers needs.
- The size and pattern of growth of home demand.
- The mechanism by which a nation's domestic preferences are transmitted to foreign markets.

Porter (1990a, p. 79) states: "*Nations give competitive advantage in industries where the home demand gives their companies a clearer or earlier picture of emerging buyer needs, and where demanding buyers pressure companies to innovate faster and achieve more sophisticated competitive advantages than foreign rivals*."

### 2.12.3 Related and supporting industries

Porter (1990a, p. 80) states: "*The presence of competitive supplier industries in a nation creates advantages in downstream industries in several ways*." This enables access to rapid, early and sometimes preferential access to the most cost-effective inputs (Porter, 1990a, Porter, 1990b). The biotechnology industry has many input requirements and the majority of science materials suppliers have agencies in South Africa (Mulder and Henschel, 2003).

### 2.12.4 Firm rivalry

Porter (1990a, p. 81) defines this attribute as "*the conditions which govern how companies are created, organised and managed, as well as the nature of the domestic rivalry*". National advantage results from a good match between these choices and sources of competitive advantage in a particular industry (Porter, 1990a, Porter, 1990b).

### 2.12.5 The role of government

Porter (1990a, p. 82) states that "*the real role of government in a nation's competitive advantage is in influencing the four determinants*" (factor conditions, demand conditions, related and supporting industries and firm rivalry). Government can influence each of the four determinants either positively or negatively. Factor conditions are affected through subsidies, policies towards the capital market, policies towards education and the like (Porter, 1990a). Governments are also major buyers of many products in a nation and can provide incentives to develop innovative products (Porter, 1990a). Government can shape the circumstances of related and supporting industries in countless other ways, such as control of advertising media or regulation of supporting services (Porter, 1990a). Government policies also influence firm strategy, structure and rivalry through such devices as capital market regulations, tax policy and antitrust laws (Porter, 1990a).

Porter (1990a, p. 73) states:

> *"National prosperity is created, not inherent. It does not grow out of a country's natural endowments, its labour pool, its interest rates or its currency value as classical economics insists."*
>
> *"A nation's competitiveness depends on the capacity of its industry to innovate and upgrade. Companies gain advantage against the world's best competitors because of pressure and challenge. They benefit from having strong domestic rivals, aggressive home-based suppliers, and demanding local customers."*

Porter (1990a, 1990b) suggests that pressures and challenges force companies to become innovative through this mechanism, and that the companies either become globally competitive or cease to exist. Porter's Diamond Model addresses the four attributes which he has identified as playing a critical role in competitiveness.

## 2.13 Innovation management framework

The diamond of national competitiveness has been adapted by numerous researchers, most recently by Lingela and Buys (2007), to provide the innovation management framework model.

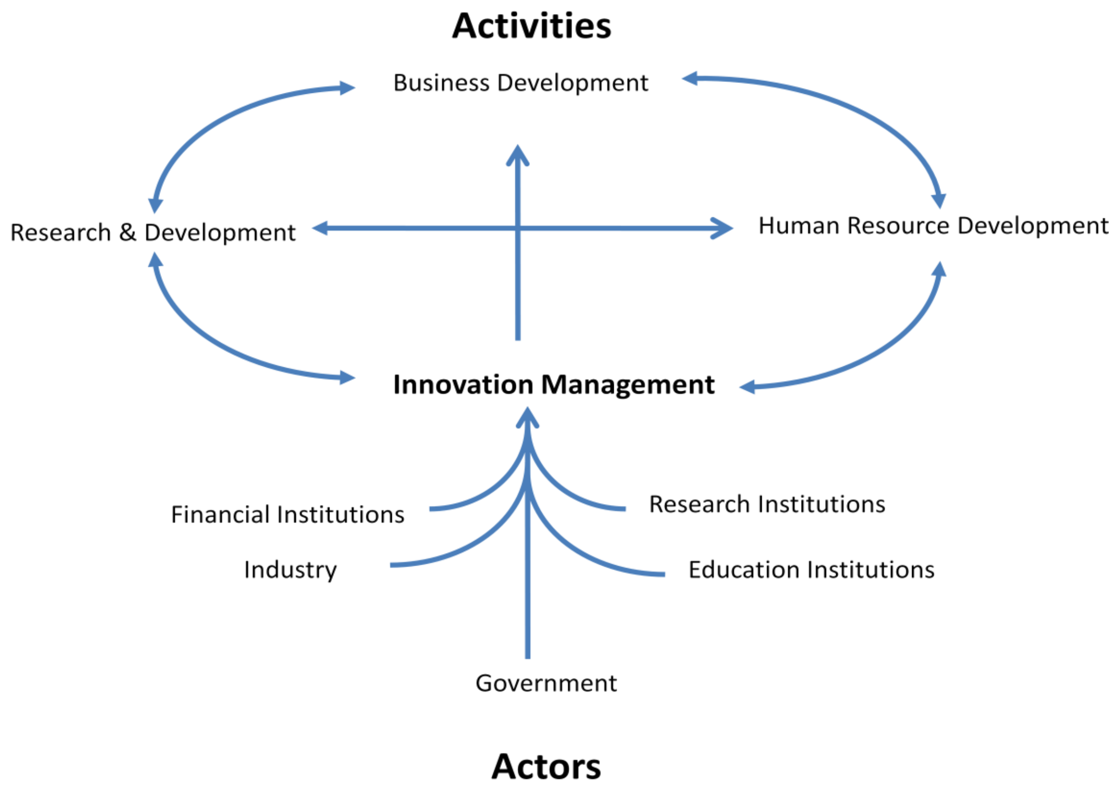


**Figure 6: Innovation management framework (Lingela and Buys, 2007)**

This model was developed to be used by innovation actors to identify and manage failures in the National System of Innovation (NSI) to improve competitiveness (Lingela and Buys, 2007). It was developed for better articulation, and identification of gaps and challenges to help improve national competitiveness. The basic inputs are innovation actors and activities. Innovation actors are defined as industry, government, educational institutions, research institutions and financial institutions (Lingela and Buys, 2007). Innovation activities are R&D activities, HR development and business development activities that are pursued by the actors (Lingela and Buys, 2007). Such a framework will enable one to identify the strengths, weaknesses and competitiveness of a sector. The innovation management framework is a model very similar to Porter's Diamond model discussed in Section 2.12.

## 2.14 National System of Innovation

The National System of Innovation (NSI) literature provides the main elements of the conceptual framework for analysing country-specific factors influencing the innovative capabilities of companies (Senker, 2004). The concept of a national innovation system goes well beyond the mere establishment of necessary organisations. It is concerned with policy and institutional arrangements, including linkages, for stimulating creativity. The key element of the NSI are the R&D systems, the role of the public sector, inter-firm relationships, the national education system and training system and the internal organisations of firms (Senker, 2004). (Senker, 2004) designed an integrative framework for assessing the national competitiveness. The four main components of the frame are (Figure 7):

- Networks of knowledge and skills
- Networks of industry and supply
- Factors connected with demand and social acceptability
- Factors connected with finance and industrial development.

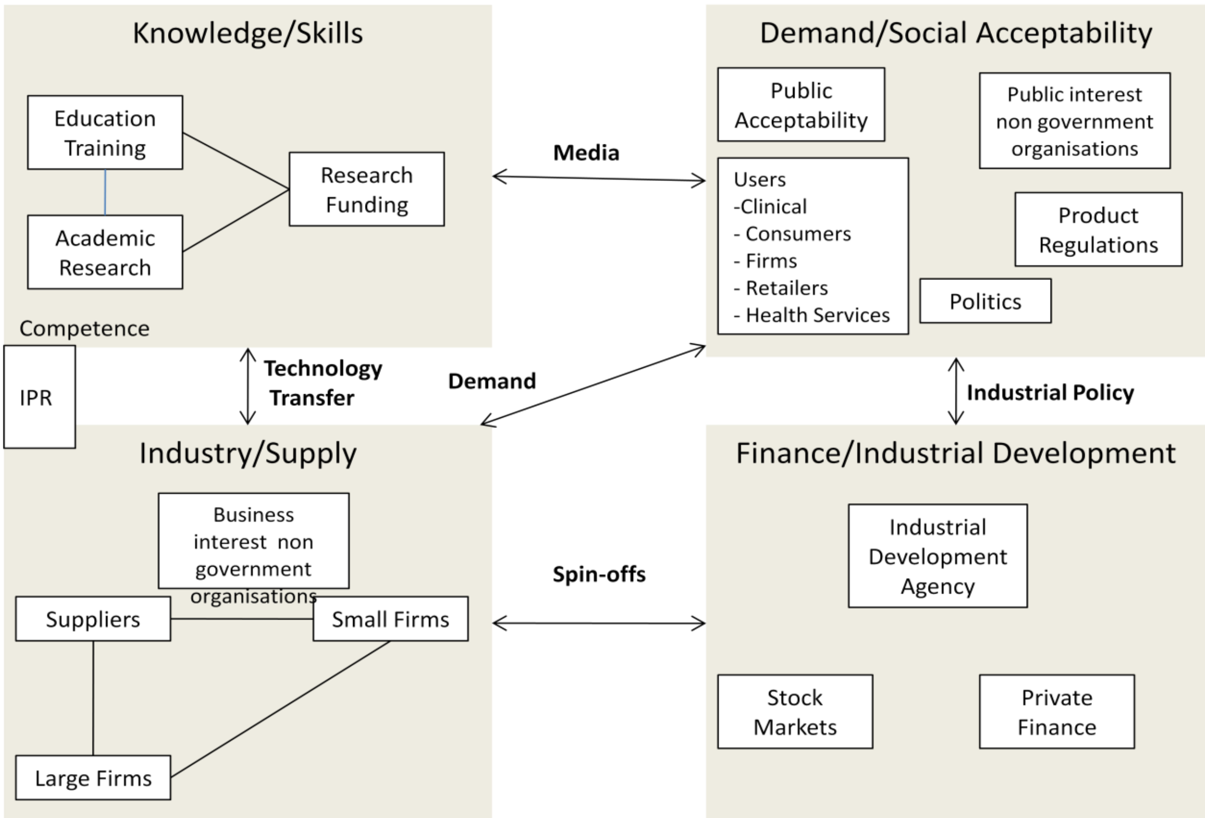


**Figure 7: Integrated framework with a network of key factors influencing innovation (Senker, 2004)**

***Knowledge/skills network***

The knowledge skills network refers to policies of government for the science bases, including investment in public sector research (PSR) and post-graduate training, instruments to promote technology transfer and intellectual property regimes for public sector research (Senker, 2004).

***Finance and industrial development***

Do countries have a range of policies to support industrial innovation in general? These can be specific biotechnology policies (Senker, 2004). These policies generally support the transfer of research results to existing industry or start-up companies.

***Demand and social acceptability***

Issues with regard to public acceptance and debates on the new technology: do the activities of public interest non-government organisations (PINGOs) affect the activities of the industry? (Senker, 2004).

***Industry/supply***

This section deals with information relating to research equipment and supplier sector information. Information regarding market size and growth rates of a particular sector are assessed (Senker, 2004).

## 2.15 Clustering

The notion of similar organisations occupying a localised geographical space is not new and can be traced back to Alfred Marshall in 1890 (cited in Porter, 1998 and Martin and Sunley, 2003) who studied and published an article entitled "The Principles of Economics". According to (Porter, 1998a), Marshall identified three factors important for localisation:

- Skilled labour
- Growth of supporting trade
- Specialisation of different firms in different stages and branches of production.

Porter (1998, p199) defines clustering as "*geographic concentrations of interconnected companies, specialised suppliers, service providers, firms in related industries and associated institutions in particular fields that compete and also cooperate*".

The world competitive report suggests that in order for countries to be competitive, they should support a cluster approach that confines state intervention to creating competitive conditions, infrastructure development and an environment that champions adaptation of existing technology (Garelli, 2003).

(Porter, 1998a) demonstrated that the world has become dominated by cluster-critical masses in one place of unusual competitive success in particular fields, based increasingly in 'cluster resources' made up of local knowledge, relationships and motivation, that makes it difficult for competitors or new entrants to match.

The clusters broaden to include government and institutions such as universities and science councils, and trade associations that provide specialised training, education, information, research and technical support. As globalisation makes the world smaller and geographic locations less relevant, cluster theory emphasises that competitive advantage rests on making more productive use of available inputs.

### 2.15.1 Cluster impact on competition

(Porter, 1998a) identifies clusters as having the following impacts on competition:

- A cluster increases productivity of companies within the region as inputs can be sourced, information and technology accessed and co-ordinated with related companies.

- A cluster can drive the direction and pace of innovations, and give access to specialised information regarding the market, employees, suppliers and specific technology which accumulates within a cluster. This would be of great benefit as information can then be shared.

- A cluster stimulates the formation of new businesses as clusters are a better alternative to vertical integration, which would expand and strengthen the cluster itself, creating a reinforcing effect and having positive job and economic effects. Clusters can also intensify competitive pressures as peer pressure can be a motivating force.

Clustering has a range of benefits for developing nations with limited resources. It creates local collaboration and cooperation as a collective capacity with a sector, which strengthens the ability of the cluster to compete in the market by sharing costs and by engaging in joint tasks such as shared research, development, marketing and distribution (Ndhlovu, 2007).

The critics of clustering argue that clustering is not clearly defined "as to what a cluster is" and it has become a 'chaotic concept' without any clear boundaries, both industrially and geographically (Martin and Sunley, 2003). Although there is criticism of the cluster concept (Martin and Sunley, 2003), it remains a useful tool for assessing and developing industry strategy and has been utilised by national governments and organisations across the world (Martin and Sunley, 2003).

## 2.16 Conclusion

This chapter began by introducing biotechnology, went on to describe the global biotechnology industry and then followed with a brief case analysis of three successful biotechnology regions, namely the US, Europe and Cuba. The key findings in developing a successful biotechnology industry were identified and discussed. The current literature on the South Africa biotechnology sector was then discussed.

The term national competitiveness was then introduced and three models were described to measure the successfulness of a sector. Competitiveness at a nation level is best argued using an industry cluster. Of importance was the South African biotechnology strategy, which was formed with a similar notion of clustering with the different regional BRICs at the core. In order to assess the success of this strategy it is important to complete a baseline analysis of the biotechnology sector.

The work of (Garelli, 2003) was found to be unsuitable to use in measuring competiveness in South Africa's biotechnology sector as the input factors were financial in nature. Owing to the small size of the sector, it was felt that just using economic measurements would be inappropriate.

The studies of (Senker *et al.*, 2007, Lingela and Buys, 2007) introduced a national innovation system model. The model of Senker *et al.* (2007) has four main components (Figure 7), namely networks of knowledge and skills; networks of industry and supply; factors connected with demand and social acceptability; and factors connected with finance and industrial development. These four components are very similar to those of the seminal work of (Porter, 1990b) in his theory on competition and cluster formation (factor conditions, firm rivalry, demand conditions, related and supporting industries) with very little additional attributes.

Similarly the work of (Lingela and Buys, 2007) has created basic inputs called innovation actors and activities. Innovation actors are defined as industry, government, educational institutions, research institutions and financial institutions (Lingela and Buys, 2007). Innovation activities are R&D activities, HR development and business development activities that are pursued by the actors (Lingela and Buys, 2007). Again the characteristics of the framework are very similar to the seminal work of (Porter, 1990b) on competition and cluster formation (factor conditions, firm rivalry, demand conditions, related and supporting industries) and is only presented in a different style with very little additional information.

The models of (Lingela and Buys, 2007, Senker *et al.*) are both shown to be similar to Porter's Diamond model on country competitiveness (Porter, 1990a, Porter, 1990b). Based on the similarity, the Diamond model was felt to be the most appropriate model to use.

While it is accepted that conditions vary from country to country and industry to industry, Porter's Diamond model is the most suitable model to complete such an analysis and will therefore be used as the theory base.

# Chapter 3 Research Propositions

This chapter identifies the propositions and research questions to be answered in the research study. The propositions are only stated without explanation in this chapter, but follow the literature from the preceding chapter.

The literature studies indicated that Porter's Diamond model is a good tool for accessing national competitiveness as it is able to access clusters and industries within a country. The diamond describes four broad attributes which together, when optimal, can lead to an industry becoming competitive.

This research will assess the state of the industry in terms of the four broad attributes. The research will address the following five propositions:

**Proposition 1:**
Factor conditions are a problem for South African biotechnology institutions or firms.

**Proposition 2:**
Demand conditions within the South African biotechnology sector are poorly developed.

**Proposition 3:**
Firm rivalry is poorly developed in the South African biotechnology industry.

**Proposition 4:**
There is a deficiency in related and supporting industries for biotechnology institutions or firms in South Africa.

**Proposition 5:**
South African biotechnology institutions or firms have no interest in the establishment of a dedicated biotechnology science park.

# Chapter 4 Research Methodology

This chapter covers the process and methodology used in the research, including a discussion on the population and the sample selection. The chapter further explains the approach adopted towards the formulation of the semi-structured interviews.

## 4.1 Research design

The objective of this research was to identify the conditions and the state of the biotechnology sector in the country. The study aimed at exploring and investigating the competitiveness of the biotechnology strategy. According to (Zikmund, 2003), when a researcher has limited experience and knowledge about a research issue, exploratory research is a useful start to ensure a more rigorous, more conclusive future study. Although two previous studies ((Donninger, 2006, Mulder and Henschel, 2003) on the biotechnology industry were done, both studies simply looked at the state of the industry at a point in time, and neither looked at the success of the strategy.

With an update on the strategy expected in 2008, it was an appropriate time to determine its impact over the last seven years and to explore the attitudes and perceptions of operators and stakeholders in the industry (Glick, 2008). With the biotechnology strategy in the process of being reviewed, an in-depth study was required to probe into the details of its success or failure. (Leedy and Ormrod, 2001) recommended a qualitative design when a researcher wants to probe deeper into the research questions and not just skim the surface.

In-depth expert interviews were conducted with senior members in the biotechnology sector (a definition in of a senior member is give in Section 4.3). Additional background information was obtained from publications in peer-reviewed journals, public documents on strategy in the sector, and policy documents. Qualitative research in the form of in-depth expert interviews was proposed because this enabled the researcher to probe and observe respondent reactions to questions and the ease with which answers were given (Saludadez and Garcia, 2001).

It was not expected that this research would provide conclusive evidence, and thus subsequent research will be required to further test and develop the ideas generated from this paper. However, this research is expected to provide a textured review of the issues that should be considered at policy, strategic and research levels in the future.

The added advantage of using a qualitative framework was that it was a more flexible and iterative style of eliciting responses that allowed the order of questions to be slightly modified during data gathering, which facilitated the investigation of important new issues and the removal of unproductive areas from the research plan (Ndhlovu, 2007).

## 4.2 Population of relevance

The population of relevance consisted of all those people who had worked in the biotechnology sector since the inception of the strategy in 2001. It comprised government agents from the Department of Science and Technology (DST), heads of the BRICs (Lifelab, BioPAD, Cape Biotech and Plantbio), biotechnology academics from universities and science councils, biotechnology venture fund capitalists and biotechnology industry players in South Africa. The size of the population was unknown as figures were unavailable from the Department of Labour, but it was deemed to be sufficiently large.

## 4.3 Sampling and unit of analysis

The unit of analysis was all the people involved in the biotechnology sector from 2001. Due to the small size of the biotechnology industry in South Africa the sampling could not be random. (Zikmund, 2003) defines non-probability sampling as “A sampling technique in which units of the sample are selected based on the basis of personal judgement or convenience.” Non-probability sampling was thus used.

It is acknowledged that the probability sampling method is inherently subjective and while there was a risk that conclusions or findings may not typically represent the relevant population, attempts were made to mitigate some of these biases by using purpose sampling techniques (Welman and Kruger, 2001). (Zikmund, 2003) defines purposive sampling as “A non-probability sampling technique in which an experienced individual selects the sample based upon some appropriate characteristics of the sample members.” According to (Welman and Kruger, 2001), non-probability purposive sampling requires researchers to rely on their experience and ‘ingenuity’ to deliberately obtain units of analysis in such a manner that the sample they obtain may be regarded as being representative of the relevant population. The target population was those members in senior management and senior researcher positions within the biotechnology industry. Senior management/researcher in this study was defined as a person occupying a COO, CEO, or director position within the biotechnology sector. Senior researcher in this study was defined as a person with at least seven years' experience in a research and development environment and who has been the principal investigator in a biotechnology funded project.

## 4.4 Sample size

Twenty-six individuals at senior management level spanning the four BRICS, government, academia and industry were identified and contacted. Twenty agreed to participate in the study. Nineteen one-on-one interviews were conducted and one interview was conducted telephonically. Due to the sensitivity of the information submitted by the stakeholders for the survey, the confidentiality of the information was maintained and the respondents' names are not disclosed. Instead a list of organisations participating in the study is given in Appendix B. It is important to note that the findings are the personal views of the respondents who have taken part in the study and not necessary the view of the organisation they represent.Only the aggregated data from the survey was used in the report. No information on, or any which is identifiable with, individual companies or organisations was used, except where this information was publicly available, i.e. on websites, in brochures, public reports, etc., or where approval was given by the organisation in question.

## 4.5 Data collection

### 4.5.1 Data collection, data analysis and data management

Data collection and data analysis in qualitative studies can be viewed as an iterative process. This enables a deeper understanding as the process progresses. The data collection, analysis and management processes that were followed to achieve the required quality of results was as follows:

- An interview guide was developed and pre-tested (Appendix A)
- Each interview was recorded and transcribed.
- The notes captured were developed into mind maps and themes developed based on the words used.

- A second mind map of the emerging theme was developed.

- An overview sense of the data was obtained until meaning for the data could be found.

- The steps above were repeated until the data had been thoroughly analysed and no new themes or insights could be identified.

### 4.5.2 Data collection

Semi-structured interviews were used (refer to Appendix A for interview guide). This method ensured that all aspects of the Diamond model were captured. Using depth interviews as a technique in exploratory research results in the subject matter being undisguised. A depth interview is relatively unstructured but enables one to probe deeply into a topic for a thorough understanding of the subject matter.

(Welman and Kruger, 2001) highlighted the pros and cons of using the face-to-face interview method to collect data.

*The advantages are:*

- The interviewer is in control of the interview process, so any misunderstandings or vague responses can be cleared up. Consequently the response obtained is of high quality.

- The response rate is very good, often better than telephonic interviews and postal surveys.

*The disadvantages are:*

- High preparation, travelling and interview costs because of the time needed.

- Interviewees may give responses that they think the interviewer wants to hear.

### 4.5.3 Data analysis

The data analysis in the qualitative research was similar to a transformation process in which a researcher takes the data and applies his analytical mind and powers to emerge with the findings. This process was highly subjective, and it was not always possible to determine the 'true' interpretation. The analysis method used in this study was a combination of constant comparative analysis and content analysis.

**Constant comparative:** Due to the iterative nature of the data collection, the data analysis process demanded a constant comparative data analysis method, wherein new data were compared with the old data. This method was used after each interview process to identify potential themes emerging from the interviews.

**Content analysis:** A detailed analysis was made of the contents of the data: looking at the transcripts and mind maps together with the notes, trying to identify the frequency of use of certain words. These were totalled and presented as a frequency table.

Both methods were used in combination and were continuously evaluated. As there was no 'correct' way of analysing the data, this process was found to be highly iterative.

## 4.6 Data validity and reliability

Qualitative research provides information that requires interpretation of the findings and is typically judgemental. It is subject to considerable interpreter bias. To overcome this bias and to introduce rigour into the study an outsider was consulted. The data were presented to him to determine whether the results were reasonable. This reduced researcher bias.

Secondly, bias due to expert's beliefs may have made the samples unrepresentative, therefore projecting the data beyond the sample would have been inappropriate.

## 4.7 Potential research limitations

The study was characterised by a number of limitations. Firstly, the research was focused only on senior management involved in the biotechnology sector. It would have been advisable to speak to stakeholders at lower levels in the sector as well to determine if the strategy has had any impact in the lower levels.

Secondly it would have been useful to obtain opinions from international organisations involved in biotechnology to gauge their opinion on the biotechnology sectors competitiveness.

Thirdly, during the semi-structured interviews the respondents often steered the discussion into a direction that mirrored their interests and concerns. While every effort was made to adhere to the guiding questions and elicit responses to these, this was not always completely possible. I do not see this as a short coming, however, and believe that the nuanced and multifaceted responses from the interview participants helped to provide a rich and multifaceted discussion on the issues at hand.

Fourthly the research was intended as an exploratory study and as such not intended to provide conclusive answers nor should it be considered to be a case study of the Biotechnology industry in South Africa.

The researcher covered all costs associated with the research. The research was focused on institutes and organisations mainly in Gauteng due to travel costs being too high to interview people outside the province.

Regarding the general research design, the proposed non-probability sampling method is inherently subjective and may not represent the relevant population.

# Chapter 5 Research Findings

This Chapter describes the findings from the data collected thorough the research. The chapter reports only on the findings without any analysis.

## 5.1 Overview of the data analysis process

This chapter details the results of the application of the Porter's Model framework to the data set as outlined in the previous chapter. The focus on this section is not to interpret the information but to detail and outline the key findings of the process used for framework analysis. The following chapter will provide insight and interpretation into the findings.

This chapter begins by presenting the stakeholder profiles of the respondents and thereafter the results contained in as outlined in Chapter 3 namely:

Proposition one

- Recruitment of skilled biotechnology workers easy
- Funding for biotechnology projects easy or difficult
- Physical infrastructure is available and easy to locate and access

Proposition 2

- Customers are locally based
- Public understanding of Biotechnology

Proposition 3

- Local competitors
- Overseas competitors

Proposition 4

- Strong network with other biotechnology organisations exists
- Equipment is easy to source locally

Proposition 5

- South African biotechnology institutions or firms have no interest in the establishment of a dedicated biotechnology science park

## 5.2 Descriptive statistics

### 5.2.1 Response rate

A total of 29 people were contacted to determine their willingness to participate in the study. Twenty-three of them were willing to participate in the study, however due to time constraints three later declined. This represented a response rate of 69%.

### 5.2.2 Sector data

The sample comprised individuals who were highly knowledgeable about the biotechnology industry, and who represented wide stakeholder interests with a depth and breadth of knowledge. The sample attempted to obtain the views of industry stakeholders, science councils and universities, government and venture capitalists operating within the sector.

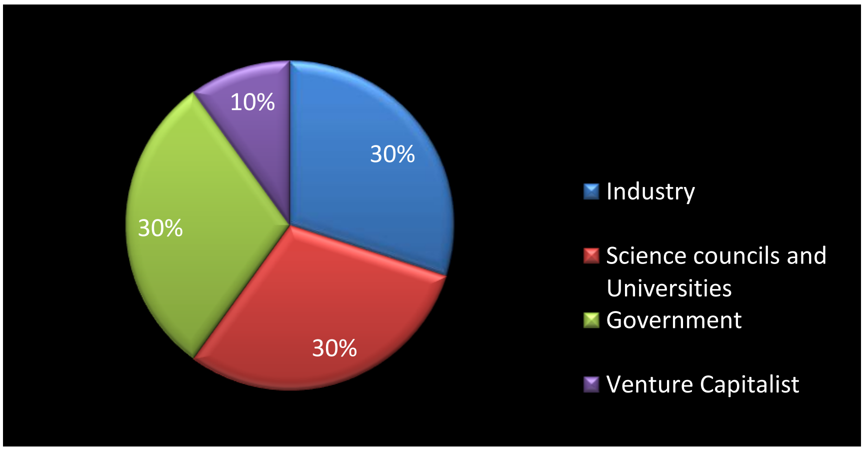


**Figure 8: Respondent breakdown based on sector represented**

The data in Figure 8 show that the respondents were equally distributed among industry, science councils and universities and government institutes, with venture capitalists representing the remaining 10%. It was important to obtain such an equitable sample considering that the research focused on an overview of the competitiveness of an industry and it had to be ensured that a balanced, representative perspective of the industry was obtained.

### 5.2.3 Years involved in biotechnology

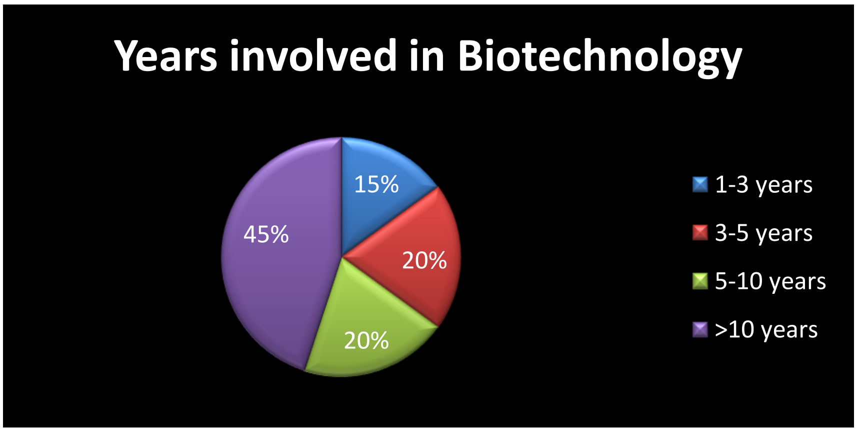


**Figure 9: Respondents' experience in the biotechnology sector**

Forty-five per cent of respondents (Figure 9) had a >10 years experience in biotechnology, which illustrates that the opinions and views expressed were from people who were extremely knowledgeable about the sector. Forty per cent of the respondents had between 3 and 10 years' experience, with the remaining 15% having less than 3 years' experience.

### 5.2.4 Position seniority

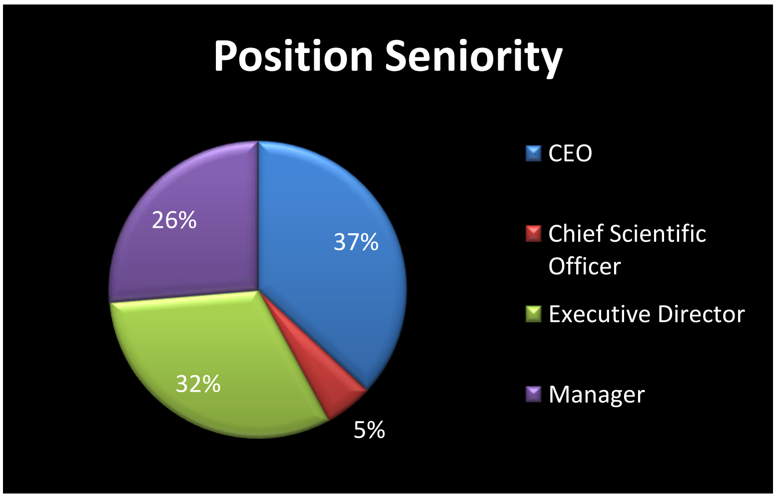


**Figure 10: Respondents' current position seniority**

The majority of respondents (Figure 10) were CEOs (37%), followed by executive directors (32%), then managers (26%).

## 5.3 Analysis of findings

### 5.3.1 Proposition 1

**Factor conditions are a problem for South African biotechnology institutions or firms**

In order to assess the above proposition, issues relating to capital, skills and infrastructure were discussed during the interviews. Specifically the following phrases were stated and the opinion of the respondent was elicited:

- Recruitment of skilled biotechnology workers is easy.
- Funding for biotechnology projects is easy or difficult to obtain.
- Physical infrastructure is available and easy to locate and access.

The results of each of the different phrases will be discussed separately and will then be analysed overall with respect to the proposition statement.

#### *5.3.1.1 Skills level availability*

This section relates to the attitudes of the respondents to the comment "recruitment of skilled biotechnology workers easy." Figure 11 represents a mind map of the key words/phrases used by the different respondents. These key words were then analysed to determine the relevant constructs, and Table 2 and Figure 12 show the frequency count per construct.

Figure 12 shows that the most common response was the construct critical mass shortage of skilled biotechnology workers (frequency = 19). A small section of the respondents (frequency = 4) felt there were sufficient skilled workers.

**Recruitment of skilled biotechnology workers is easy (Proposition 1)**

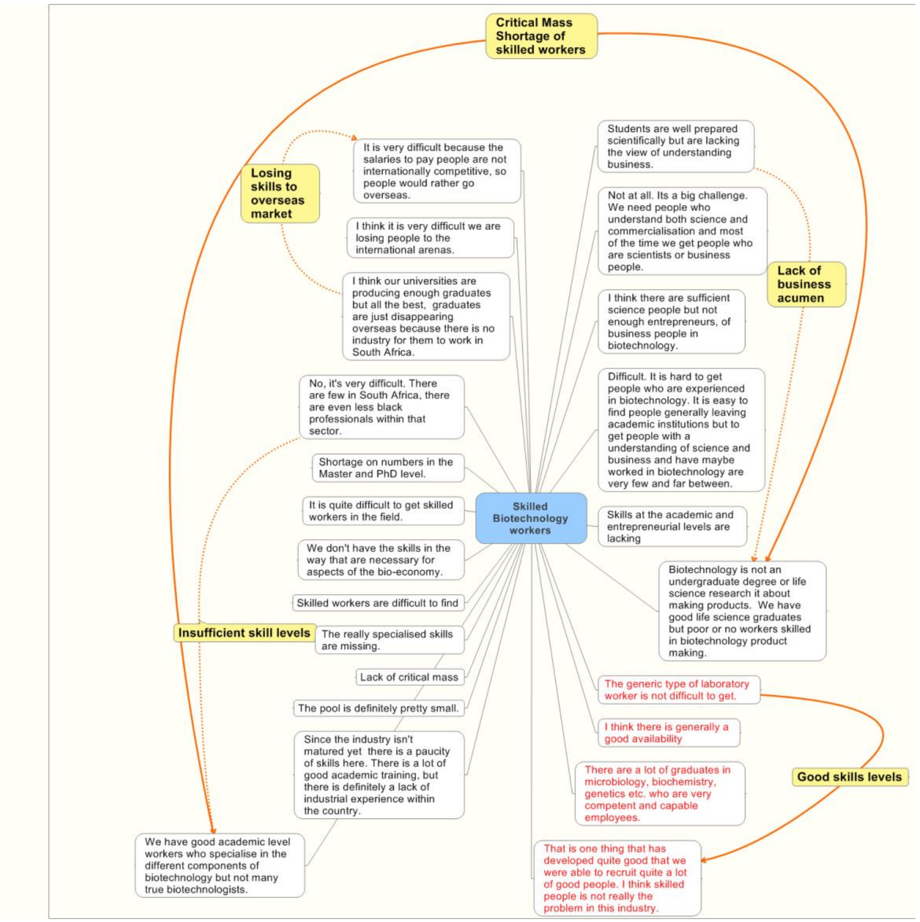


**Figure 11: Mind map of skills level and accessibility**

**Table 2: Rank order of the different constructs**

| *Rank order* | *Construct* | *Frequency* |
|---|---|---|
| **1** | Critical-mass shortage of skilled workers | 19 |
| **2** | Sufficiently skilled workers | 4 |

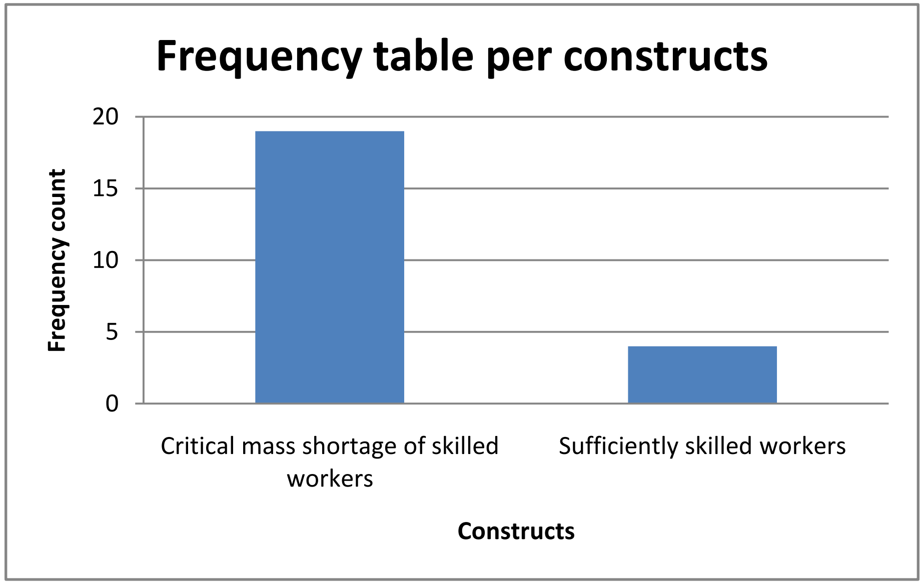


**Figure 12: Frequency table of the different constructs arising from skills levels and accessibility**

**Table 3: Sector analysis of the different constructs**

| Sector Analysis | Construct | Frequency |
|---|---|---|
| **Government** | Critical mass shortage of skilled workers | 5 |
| | Sufficiently skilled workers | 0 |
| **Industry** | Critical mass shortage of skilled workers | 6 |
| | Sufficiently skilled workers | 1 |
| **Universities and Science Councils** | Critical mass shortage of skilled workers | 6 |
| | Sufficiently skilled workers | 3 |
| **Venture Capitalists** | Critical mass shortage of skilled workers | 2 |
| | Sufficiently skilled workers | 0 |

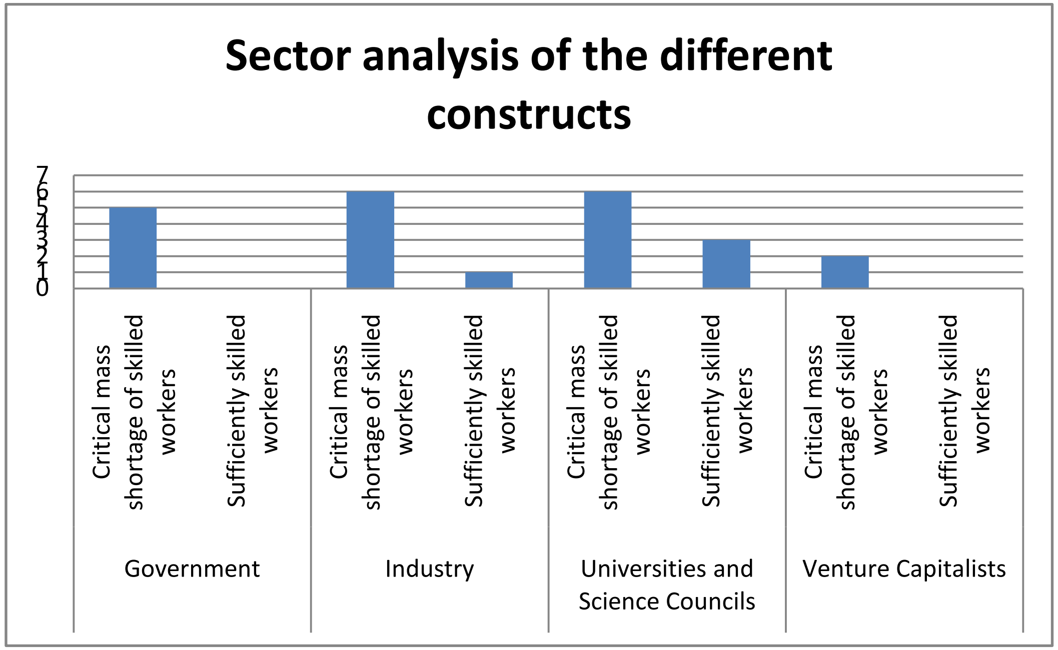


**Figure 13: Frequency table of the skill levels and accessibility of biotechnology workers per sector analysis**

A respondent sector analysis of the two constructs (Table 3 and Figure 13) showed that the majority of government, industry, universities and science councils and venture capitalist respondents were of the opinion that there is a skills shortage.

#### *5.3.1.2 Funding availability*

This section related the opinions of the respondents to the comment "funding for biotechnology project is easy or difficult". Figure 14 represents a mind map of three key words/phrases used by the different respondents. These key words were then analysed to determine the relevant constructs, and Table 4 and Figure 15 show the frequency count per construct.

Figure 15 shows that the most common response to the phrase "funding for biotechnology project is easy or difficult" was the construct that government funding is available but not being optimally utilised (frequency = 16). The second major construct to emerge was limited venture capital and private sector funding within the sector (frequency = 8). Some of the respondents (frequency = 6) felt that funding was easy to obtain within the sector.

A respondent sector analysis of the different constructs (Table 5, Figure 16) showed that government respondents felt that there was a lack of venture capital and private sector funding within the sector hampering its development. Industry respondents were evenly distributed between the three constructs, universities and science council respondents were of the overwhelming opinion that public sector funding was available but was limited and not being optimally utilised; and venture capitalist respondents were also of the opinion that public sector funding was available but was limited and not being optimally utilised.

## Funding for biotechnology projects easy or difficult (Proposition 1)

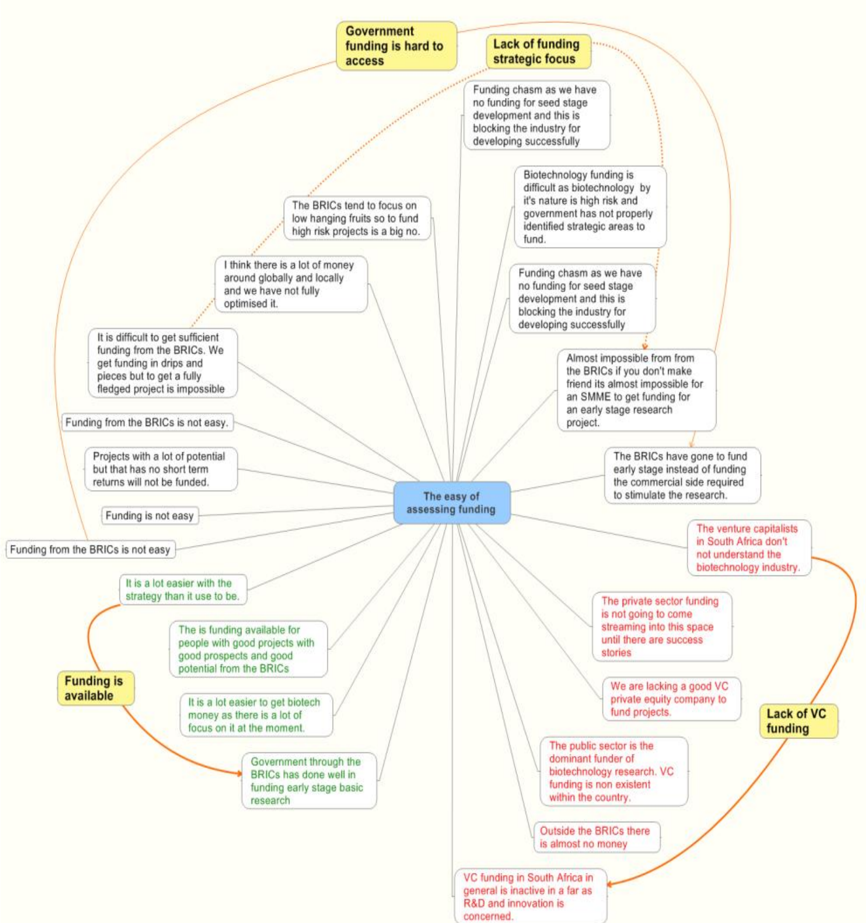


**Figure 14: Mind map of funding accessibility**

**Table 4: Rank order of the different constructs**

| *Rank order* | *Construct* | *Frequency* |
|---|---|---|
| **1** | Government funding is available but is not optimally utilised. | 16 |
| **2** | Limited Venture capital and private sector funds | 8 |
| **3** | Funding is easy to obtain | 6 |

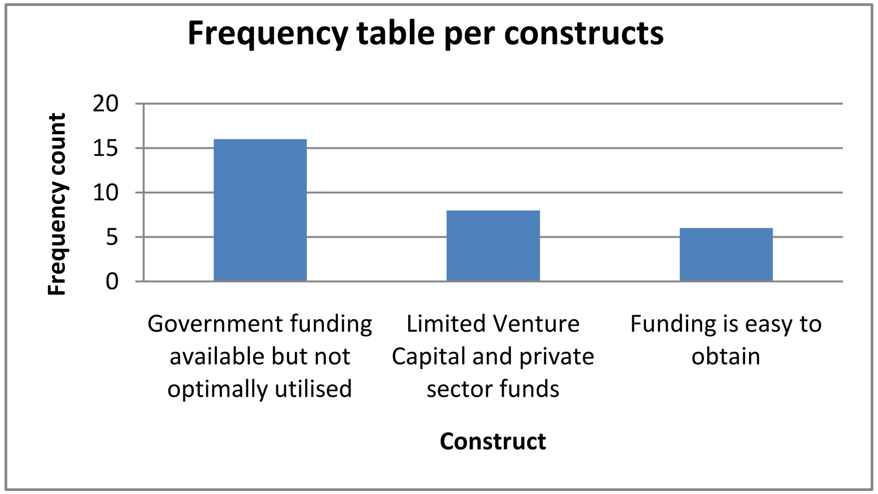


**Figure 15: Frequency table of the different constructs arising from funding accessibility**

**Table 5: Sector analysis of the different constructs**

| Sector Analysis | Construct | Frequency |
|---|---|---|
| Government | Government funding is available but is not optimally utilised | 2 |
| | Limited venture capital and private sector funds | 4 |
| | Funding is easy to obtain | 2 |
| Industry | Government funding is available but is not optimally utilised | 3 |
| | Limited venture capital and private sector funds | 3 |
| | Funding is easy to obtain | 3 |
| Universities and Science Councils | Government funding is available but is not optimally utilised | 8 |
| | Limited venture capital and private sector funds | 1 |
| | Funding is easy to obtain | 0 |
| Venture Capitalists | Government funding is available but is not optimally utilised | 3 |
| | Limited venture capital and private sector funds | 0 |
| | Funding is easy to obtain | 1 |

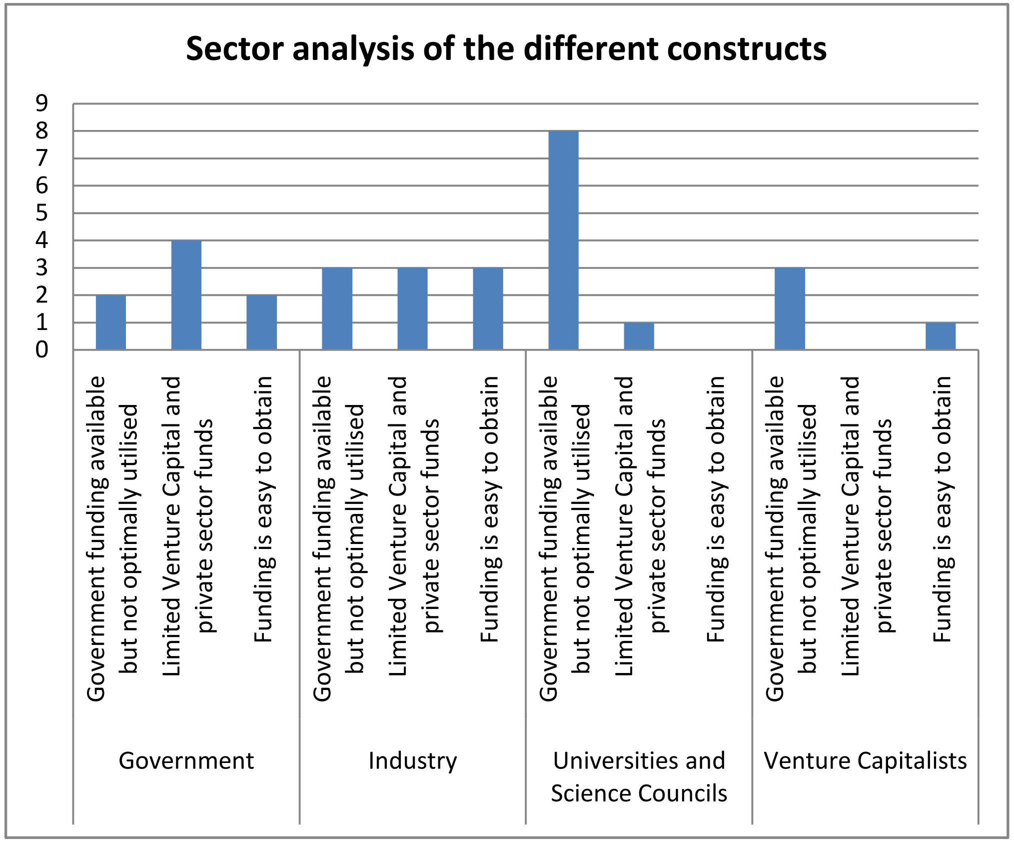


**Figure 16: Frequency table funding accessibility per sector analysis**

#### *5.3.1.3 Physical infrastructure*

This section related the opinions of respondents to the comment “physical infrastructure is available and easy to locate and access.” Figure 17 represents a mind map of three key words/phrases used by the different respondents. These key words were then analysed to determine the relevant constructs and Table 7 and Figure 18 show the frequency count per construct.

Figure 18 shows that the most common response to the phrase “physical infrastructure is available and easy to locate and access” was the construct that there is insufficient infrastructure available (frequency = 12). The second major construct to emerge was that physical infrastructure was available and accessible (frequency = 6). Some of the respondents (frequency = 3) felt that there was sufficient infrastructure within the country but it is inaccessible.

A respondent sector analysis of the different constructs (Table 8, Figure 19) showed that government and industry respondents felt that there was insufficient infrastructure within the country. University and science council respondents were of the opinion there was sufficient infrastructure within the sector and venture capitalist respondents were also split between there being insufficient infrastructure within the country and there being sufficient but difficult to access.

#### *5.3.1.4 Summary of proposition1 findings*

The major construct of the three discussion points are summarised in Table 6 below.

**Table 6: Summary of proposition 1 main findings**

| Sub-propositions | Main construct to emerge |
|---|---|
| **Skills availability** | Critical mass shortage of skilled workers |
| **Funding availability** | Public sector funding is available but is limited or not optimally utilised |
| **Physical infrastructure availability** | Insufficient infrastructure and development |

All the discussion points around proposition 1 gave a negative response. This shows that the majority of respondents were of the opinion that factor conditions are a problem for South African organisations in the biotechnology sector.

**Physical infrastructure is available and easy to locate and access (Proposition 1)**

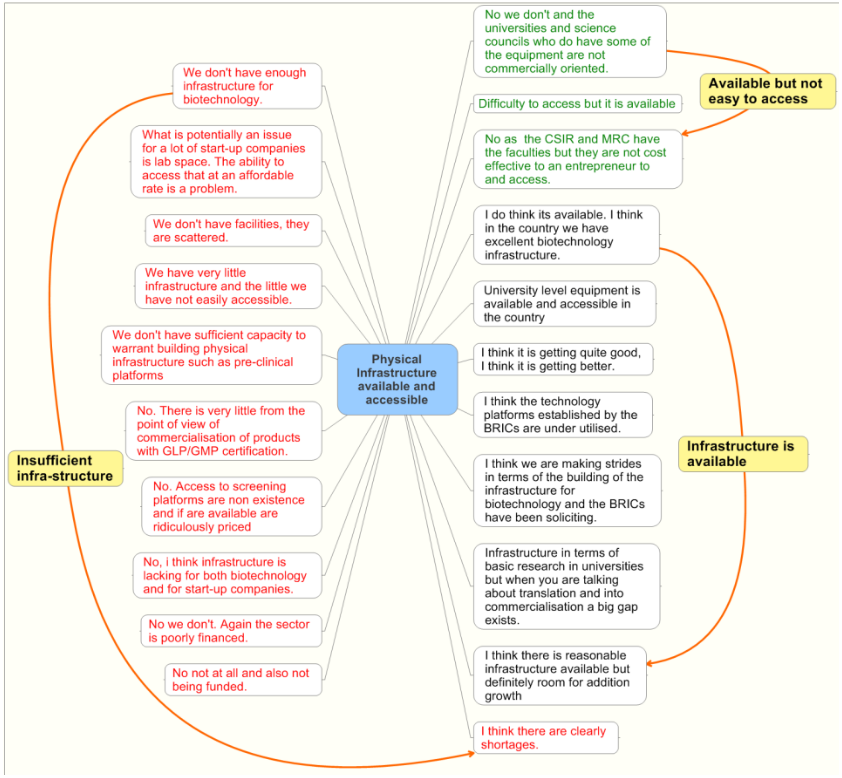


**Figure 17: Mind map of respondents' views on physical infrastructure availability**

**Table 7: Rank order of the different constructs**

| Rank order | Construct | Frequency |
|---|---|---|
| **1** | Insufficient infrastructure and development | 12 |
| **2** | Physical infrastructure is available and easy to assess | 6 |
| **3** | Physical infra-structure is available but hard to access | 3 |

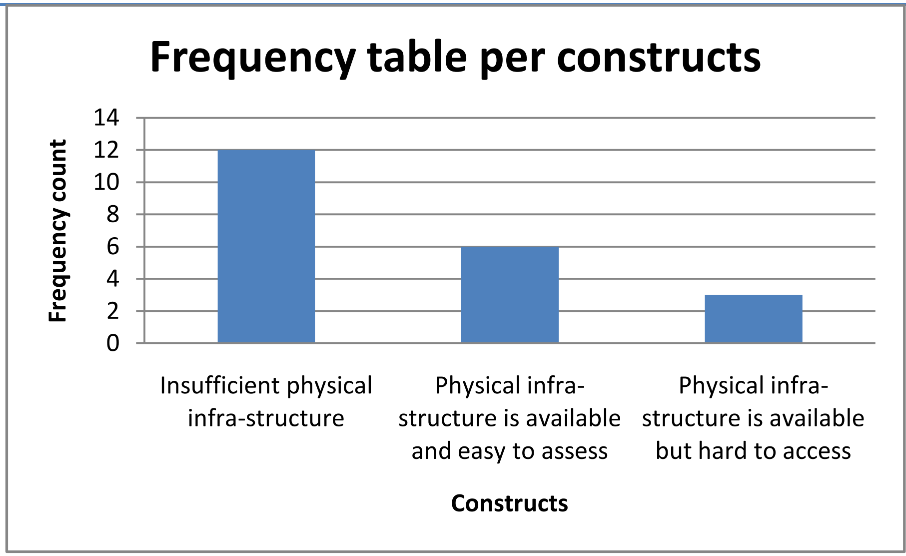


**Figure 18: Frequency table of the different constructs on physical infrastructure availability**

Table 8: Sector analysis of the different constructs

| Sector Analysis | Construct | Frequency |
|---|---|---|
| Government | Physical infrastructure is available and easy to assess | 0 |
| | Physical infrastructure is available but hard to access | 1 |
| | Insufficient physical infrastructure | 4 |
| Industry | Physical infrastructure is available and easy to assess | 2 |
| | Physical infrastructure is available but hard to access | 1 |
| | Insufficient physical infrastructure | 5 |
| Universities and Science Councils | Physical infrastructure is available and easy to assess | 4 |
| | Physical infrastructure is available but hard to access | 0 |
| | Insufficient physical infrastructure | 2 |
| Venture Capitalists | Physical infrastructure is available and easy to assess | 0 |
| | Physical infrastructure is available but hard to access | 1 |
| | Insufficient physical infra-structure | 1 |

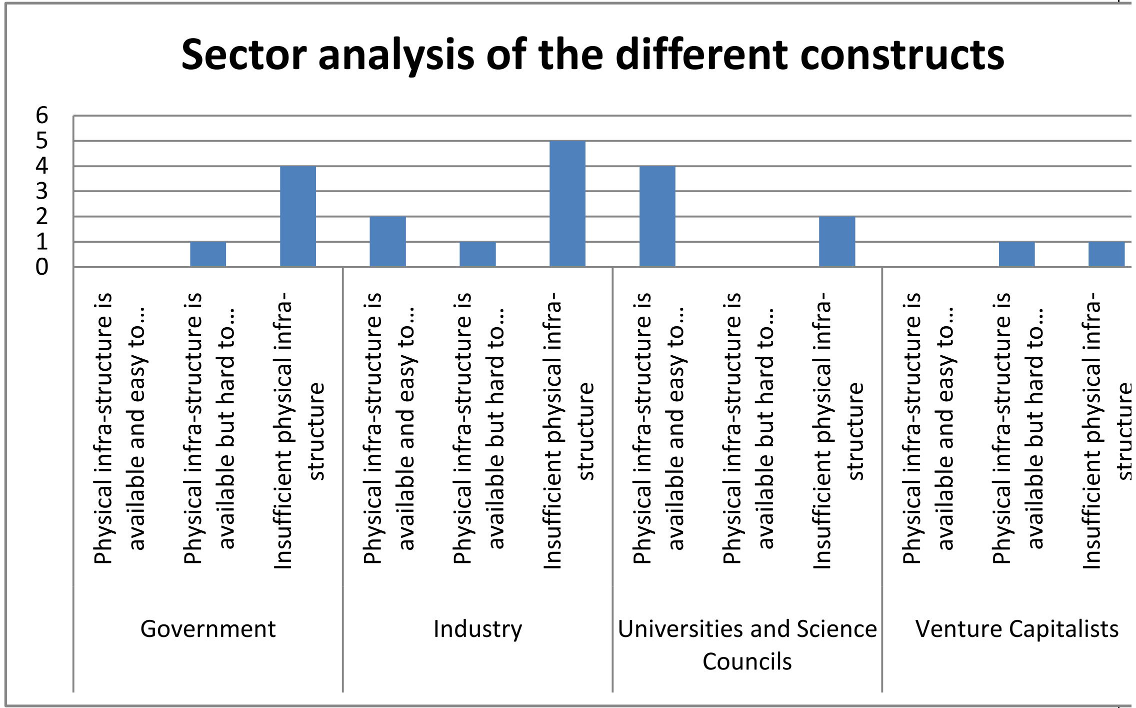


Figure 19: Frequency table of the success of biotechnology per sector analysis

### 5.3.2 Proposition 2

**Demand conditions within the biotechnology sector are poorly developed**

In order to assess the above proposition, issues relating to local customers were addressed. Specifically the following phrases were stated and the opinions of the respondents were elicited:

- Customers are locally based.
- Public understanding of biotechnology is good.

The results of each of the different phrases are discussed separately and then analysed overall with respect to the proposition statement.

#### *5.3.2.1 Customer focus*

This section related the opinions of respondents to the comment "customers are locally based". Figure 20 represents a mind map of the key words/phrases used by the different respondents. These key words were then analysed to determine the relevant constructs and Table 9 and Figure 21 show the frequency count per construct.

Figure 21 shows that the most common response to the phrase "customers are locally based" was the construct of international focus on customers (frequency = 9). The second major response was local focus (frequency =5). Some of the respondents (frequency =3) felt that there was a mixed customer focus.

A respondent sector analysis of the different constructs given in Table 9 showed that government respondents felt that there was local customer focus within the sector with products being developed for the local market needs. Industry respondents were of the opinion that their focus should be on the international market; university and science council respondents were evenly distributed among the three constructs; and venture capitalist respondents were split between an international customer market focus and a mixed customer focus.

**Customers are locally based (Proposition 2)**

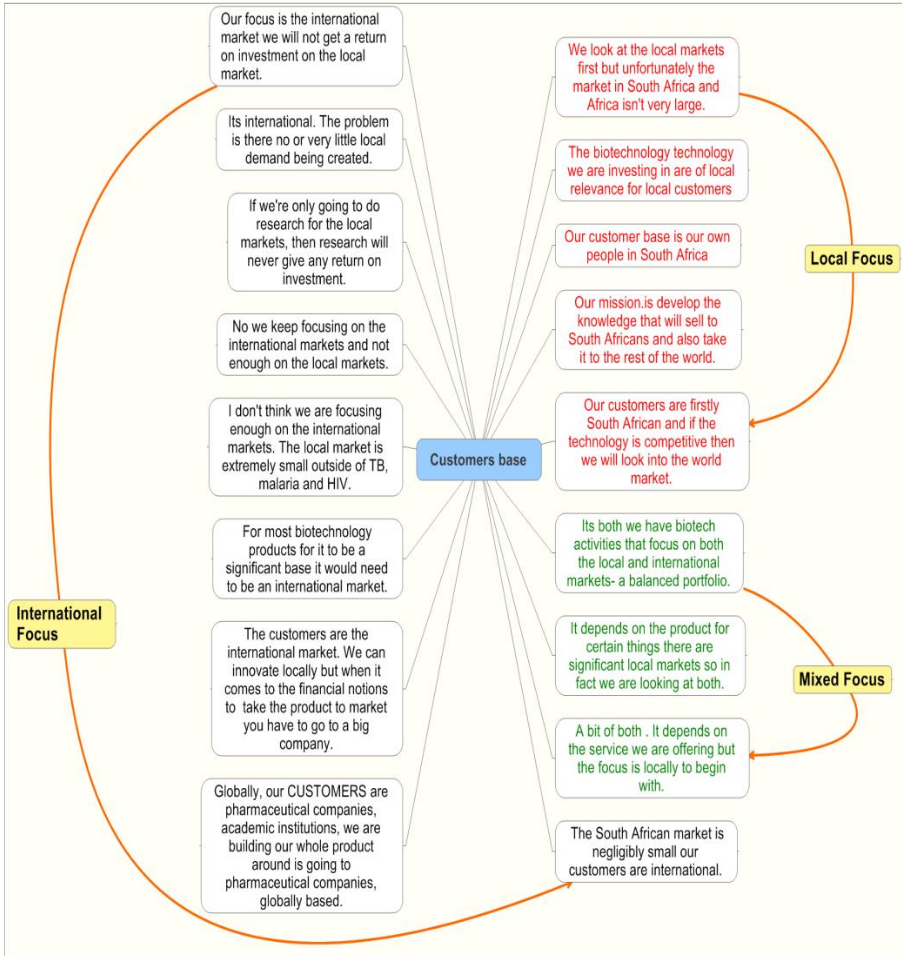


**Figure 20: Mind map of respondents' views on local customers**

**Table 9: Rank order of the different constructs**

| *Rank order* | *Construct* | *Frequency* |
|---|---|---|
| **1** | International Focus | 9 |
| **2** | Local Focus | 5 |
| | Mixed Focus | 3 |

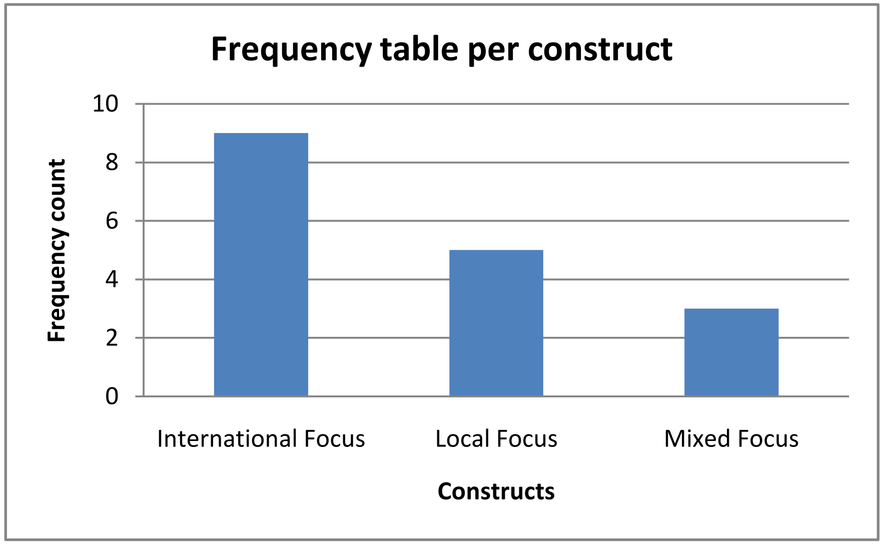


**Figure 21: Frequency table of the different constructs on respondents' views on local customers**

**Table 10: Sector analysis of the different constructs**

| Sector Analysis | Construct | Frequency |
|---|---|---|
| **Government** | International Focus | 2 |
| | Local Focus | 4 |
| | Mixed Focus | 1 |
| **Industry** | International Focus | 5 |
| | Local Focus | 0 |
| | Mixed Focus | 0 |
| **Universities and Science Councils** | International Focus | 1 |
| | Local Focus | 1 |
| | Mixed Focus | 1 |
| **Venture Capitalists** | International Focus | 1 |
| | Local Focus | 0 |
| | Mixed Focus | 1 |

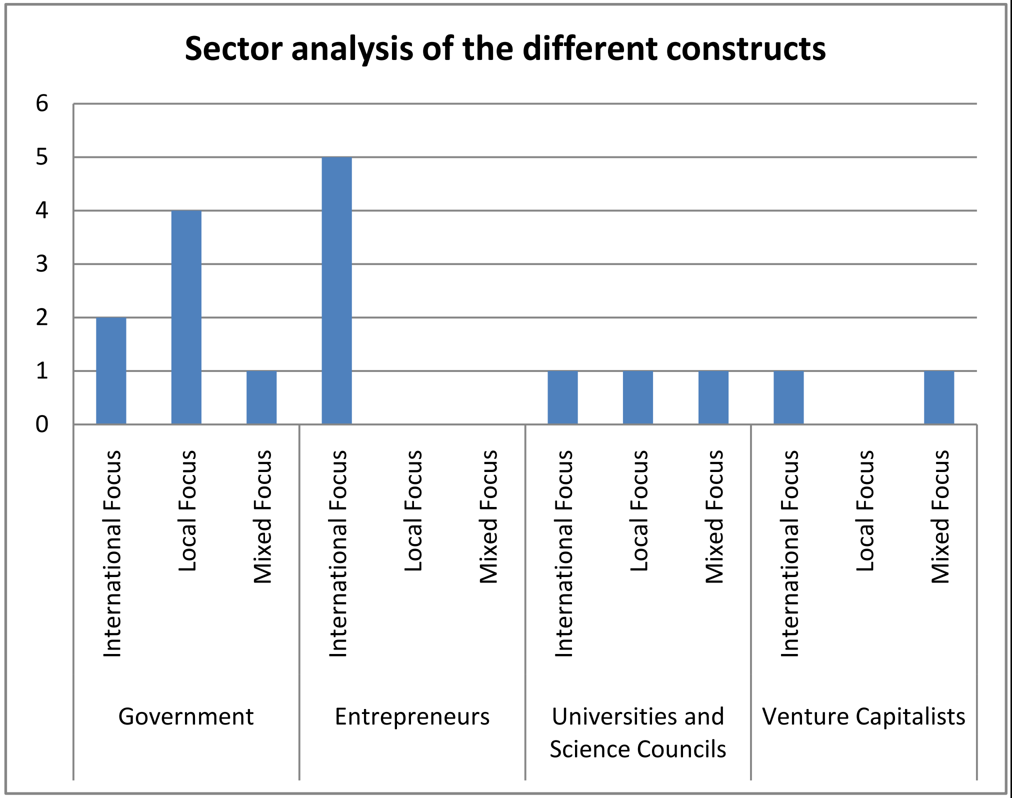


**Figure 22: Frequency table of customer focus per sector analysis**

#### *5.3.2.2 Public understanding of biotechnology*

This section related the opinions of respondents to the comment "the public has a good understanding of biotechnology". Figure 23 represents a mind map of the key words/phrases used by the different respondents. These key words were then analysed to determine the relevant constructs and Table 11 and Figure 24 show the frequency count per construct. Figure 24 shows that the most common response to the phrase "public understanding of biotechnology was good" was the construct that the public understanding was poor (frequency = 12). The second construct was that the public understanding of biotechnology was good (frequency = 5).

A respondent sector analysis of the different constructs given in Table 12 and Figure 25 showed that government respondents felt overall that the public had a good understanding of biotechnology. Industry, university and science council respondents felt that the public had a poor understanding of biotechnology and the two venture capitalist respondents were evenly split.

**Public understanding of biotechnology**

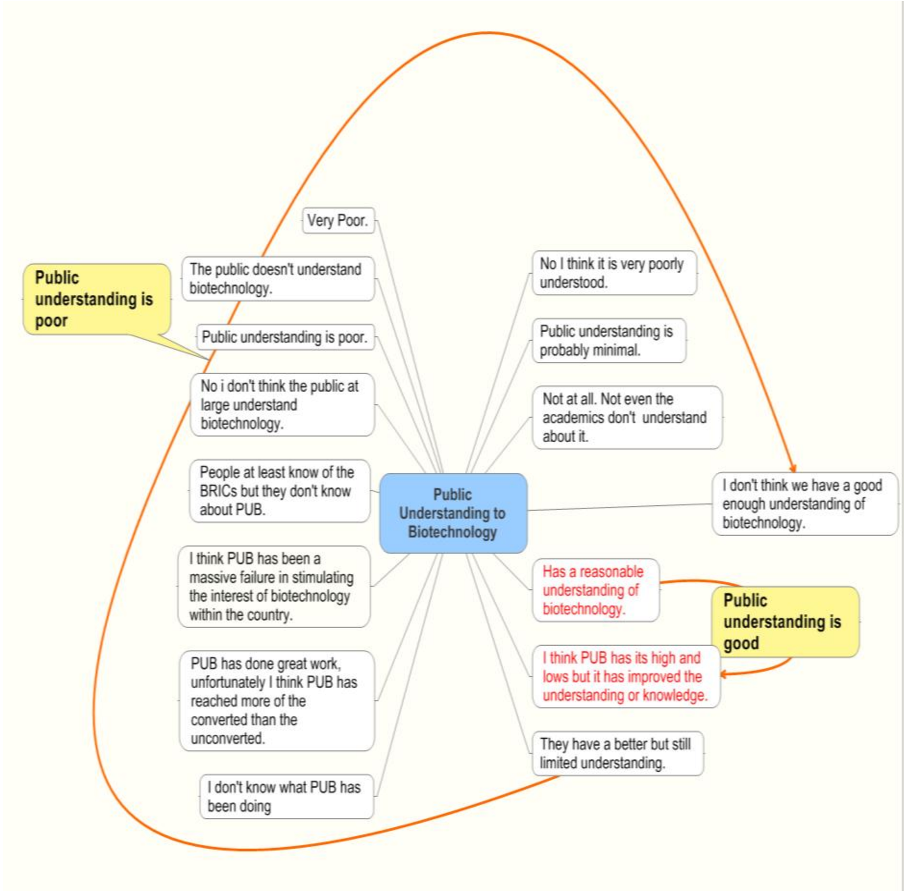


**Figure 23: Mind map of the response to public understanding of biotechnology**

**Table 11: Rank order of the different constructs**

| Rank order | Construct | Frequency |
|---|---|---|
| **1** | Public understanding is poor | 12 |
| **2** | Public understanding is good | 5 |

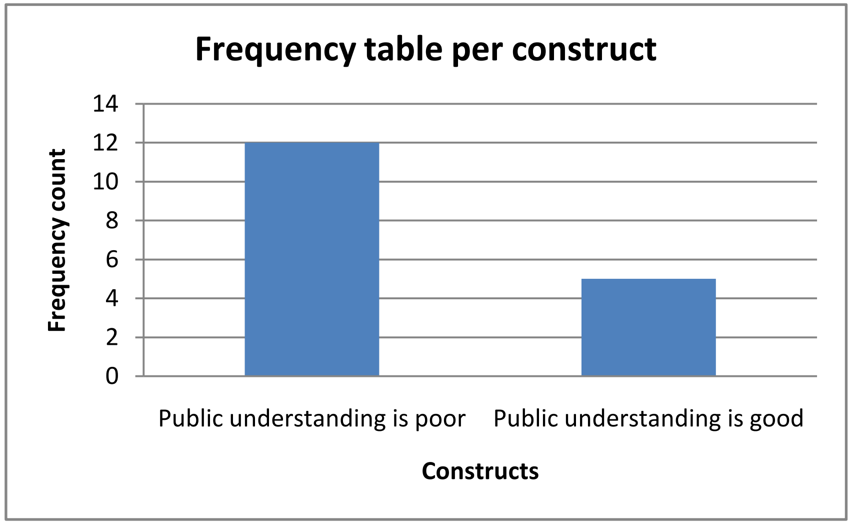


**Figure 24: Frequency table of the different constructs arising from public understanding of biotechnology**

**Table 12: Sector analysis of the different constructs**

| Sector Analysis | Construct | Frequency |
|---|---|---|
| **Government** | Public understanding is poor | 2 |
| | Public understanding is good | 3 |
| **Industry** | Public understanding is poor | 5 |
| | Public understanding is good | 0 |
| **Universities and Science Councils** | Public understanding is poor | 4 |
| | Public understanding is good | 1 |
| **Venture Capitalists** | Public understanding is poor | 1 |
| | Public understanding is good | 1 |

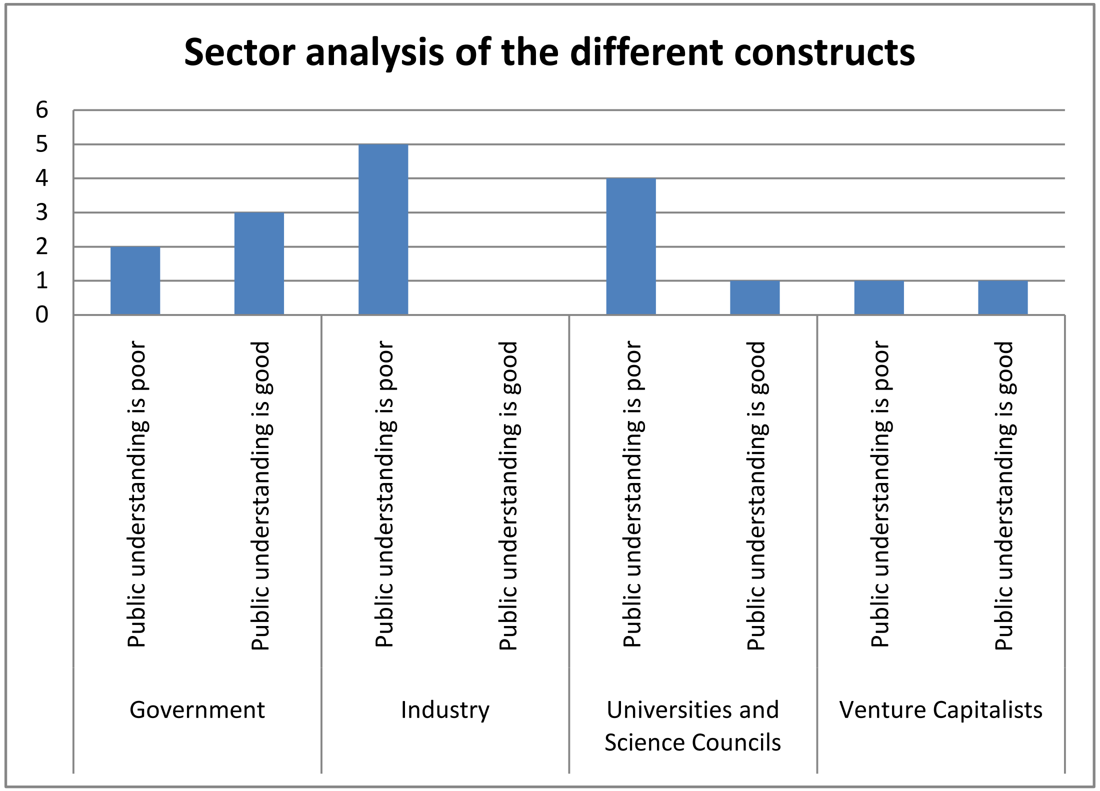


**Figure 25: Frequency table of the success of biotechnology per sector analysis**

*5.3.2.3 Summary of proposition 2 findings*

The major construct of the two discussion points is summarised in Table 13 below.

**Table 13: Summary of proposition 2 main findings**

| Sub-propositions | Main construct emerging |
|---|---|
| **Customer focus** | International customer focus |
| **Public understanding of biotechnology** | Public understanding is poor |

All the discussion points around proposition 2 gave a negative response. This shows that the majority of respondents are of the opinion that demand conditions within the South African biotechnology sector are poorly developed.

### 5.3.3 Proposition 3

**Firm rivalry is poorly developed in the South African biotechnology industry**

In order to assess the above proposition, issues relating to competitor focus were addressed. Specifically the following phrase was stated and the opinions of the respondent were elicited:

"Local competitor exists within the biotechnology sector."

Figure 26 represents a mind map of three key words/phrases used by the different respondents. These key words were then analysed to determine the relevant constructs and Table 14 and Figure 27 shows the frequency count per construct.

Figure 27 shows that the most common response to the phrase "Local competitor exists within the biotechnology sector" was the construct that local competition is weak: focus is on international competitors (frequency = 17). The second construct that local competitors are many and strong had a frequency count of 1.

A respondent sector analysis of the different constructs in Table 15 and Figure 28 show that government, industry, university, science council and venture capitalist respondents were of the opinion that South Africa had no local competition.

**Local and international competitors (Proposition 3)**

**Table 14: Rank order of the different constructs**

| Rank order | Construct | Frequency |
|---|---|---|
| **1** | Local competition is weak: focus is on international competitors | 17 |
| **2** | Local competitors are many and strong | 1 |

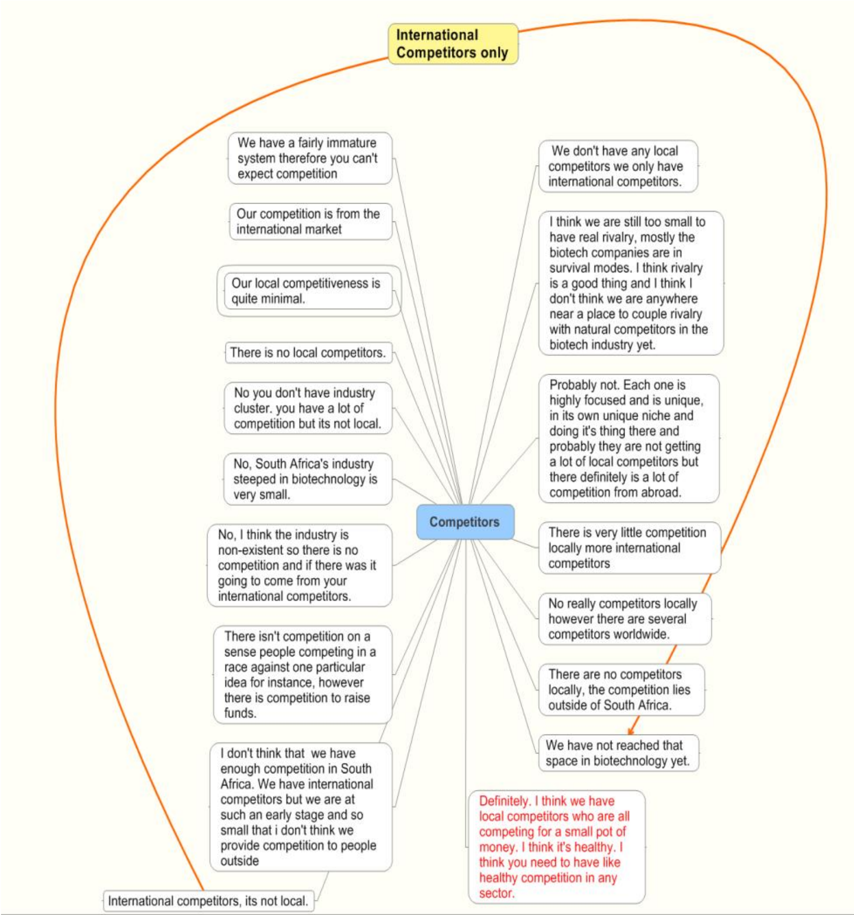


**Figure 26: Mind map of strategy success**

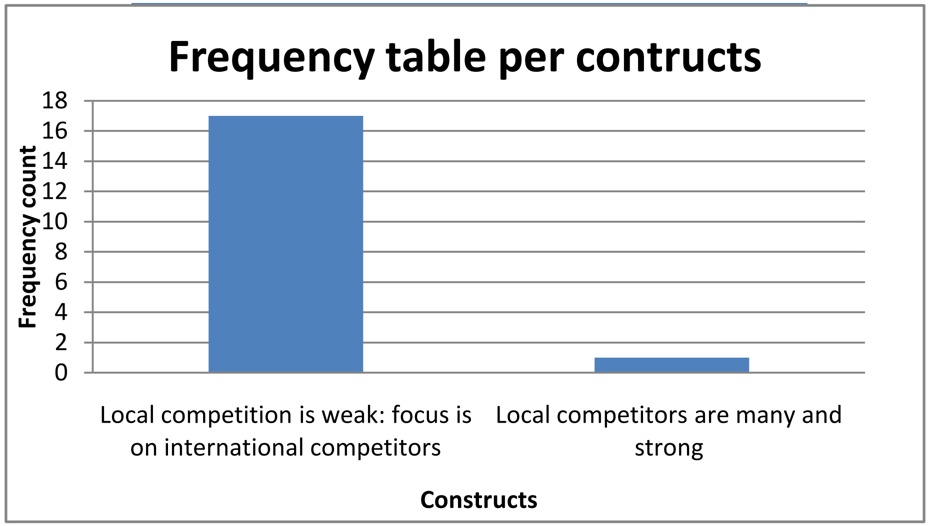


**Figure 27: Frequency table of the different constructs arising from the successfulness of South Africa's biotechnology sector**

**Table 15: Sector analysis of the different constructs**

| Sector Analysis | Construct | Frequency |
|---|---|---|
| **Government** | Local competition is weak: focus is on international competitors | 6 |
| | Local competitors are many and strong | 0 |
| **Industry** | Local competition is weak: focus is on international competitors | 4 |
| | Local competitors are many and strong | 1 |
| **Universities and Science Councils** | Local competition is weak: focus is on international competitors | 5 |
| | Local competitors are many and strong | 0 |
| **Venture Capitalists** | Local competition is weak: focus is on international competitors | 2 |
| | Local competitors are many and strong | 0 |

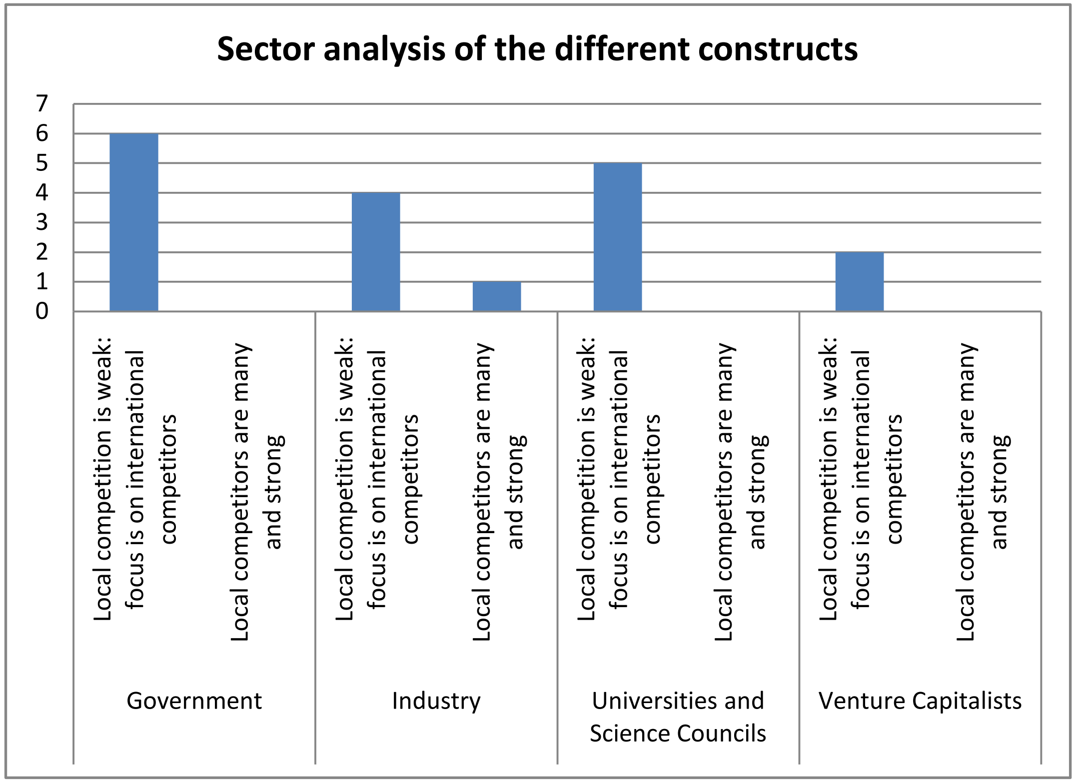


**Figure 28: Frequency table of the success of biotechnology per sector analysis**

All the discussion points around proposition 3 gave a negative response in respect of rivalry attributes of Porter's Diamond model. This shows the majority of respondents are of the opinion that firm rivalry is poorly developed in the South African biotechnology sector.

### 5.3.4 Proposition 4

**There is a deficiency in related and supporting industries for biotechnology institutions or firms in South Africa**

In order to assess the above proposition, issues relating to networking, equipment support, chemical support, etc. were addressed. Specifically the following phrases were stated and the opinions of the respondents were elicited:

- Strong network with other biotechnology organisations exists
- Equipment is easy to source locally

The results of each of the different phrases are discussed separately and then analysed overall with respect to the proposition statement.

#### *5.3.4.1 Networking*

This section related the opinions of respondents to the comment "a strong network exists within the industry". Figure 29 represents a mind map of the key words/phrases used by the different respondents. These key words were then analysed to determine the relevant constructs and Table 16 and Figure 30 show the frequency count per construct. Figure 30 shows that the most common response to the phrase "a strong network exists within the sector" was the construct that a strong network exists (frequency = 14). The second construct, fragmented or no network, had a frequency count of 7.

A respondent sector analysis of the different constructs in Table 17 and Figure 31 showed that government, industry, university and science council respondents were all of the majority opinion that a strong network exists. The venture capitalist respondents were of the opinion that the network was fragmented and limited.

## Networking with sector

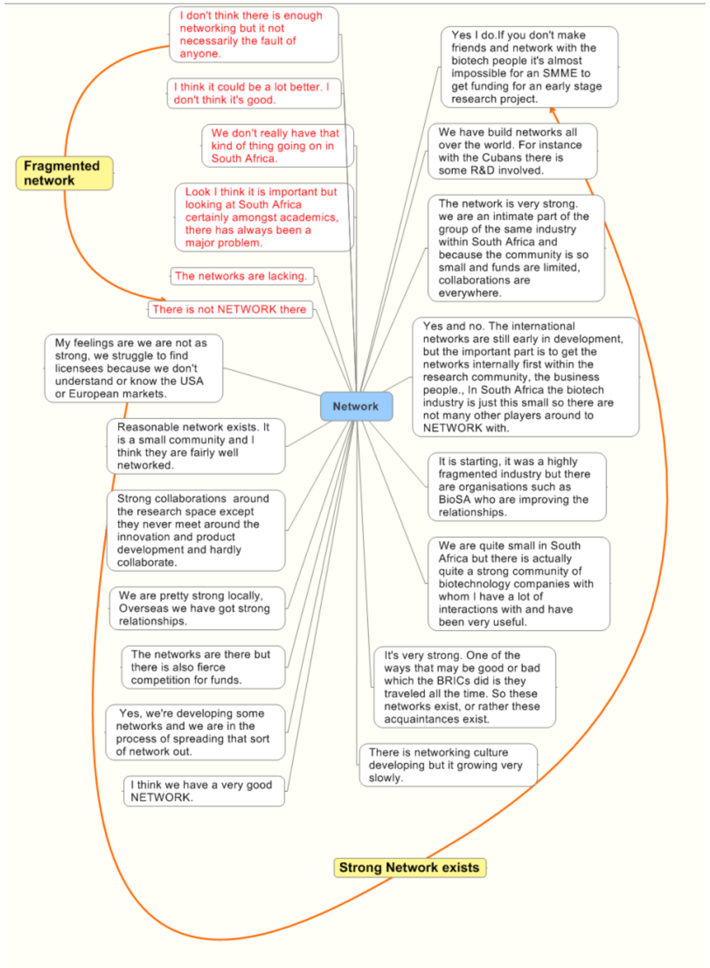


**Figure 29: Mind map of respondents' views of a network within the biotechnology sector**

**Table 16. Rank Order of the Different constructs**

| *Rank order* | *Construct* | *Frequency* |
|---|---|---|
| **1** | A strong network exists | 14 |
| **2** | Fragmented/No network | 7 |

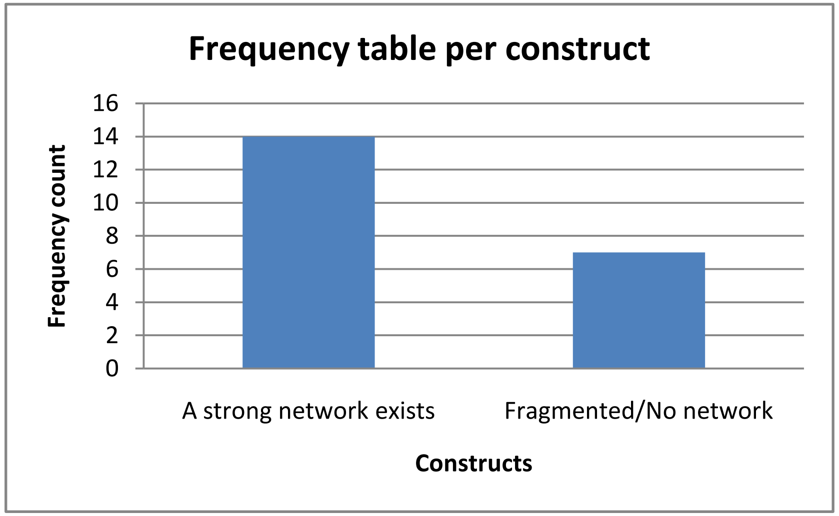


**Figure 30: Frequency table of the different constructs arising from networking within the biotechnology sector**

**Table 17: Sector analysis of the different constructs**

| Sector Analysis | Construct | Frequency |
|---|---|---|
| **Government** | A strong network exists | 6 |
| | Fragmented/No network | 1 |
| **Industry** | A strong network exists | 4 |
| | Fragmented/No network | 2 |
| **Universities and Science Councils** | A strong network exists | 4 |
| | Fragmented/No network | 2 |
| **Venture Capitalists** | A strong network exists | 0 |
| | Fragmented/No network | 2 |

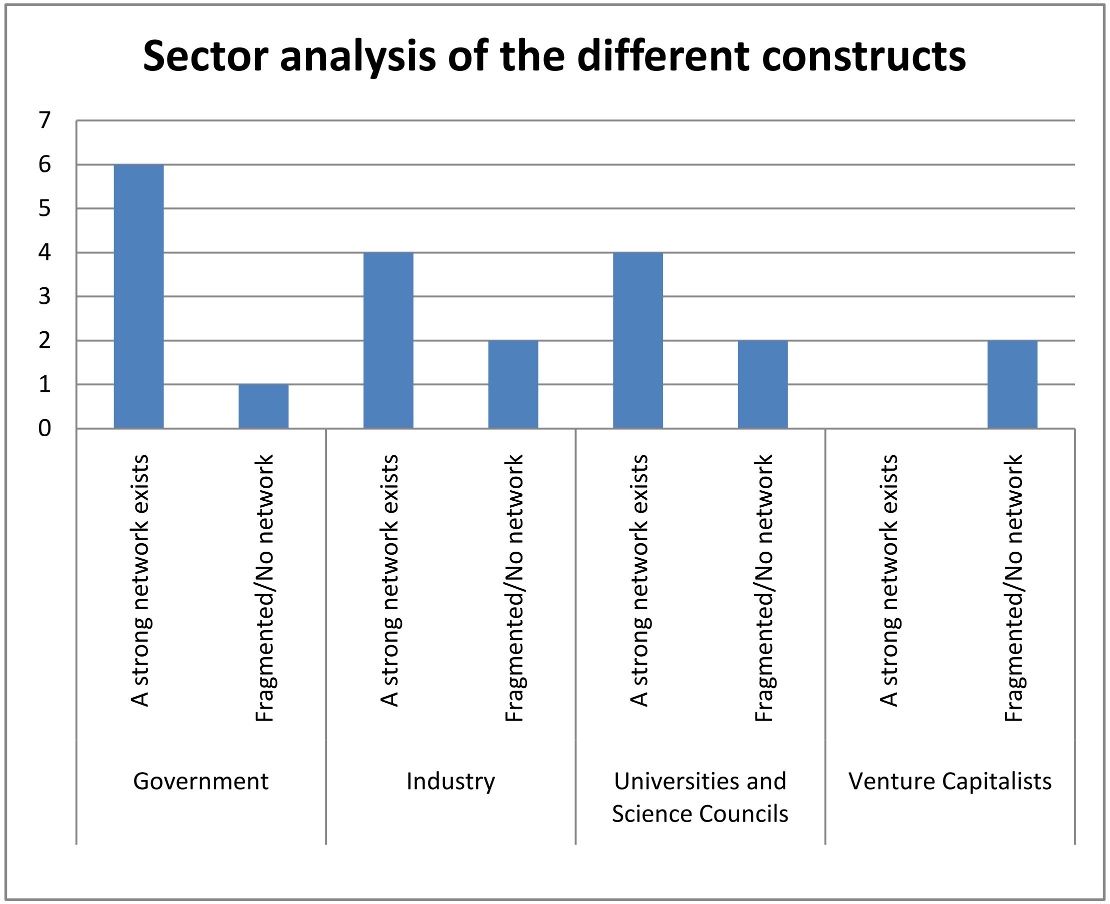


**Figure 31: Frequency table of the success of biotechnology per sector analysis**

*5.3.4.2 Local suppliers*

This section related the opinions of respondents to the comment "equipment and services are easy to source locally". Figure 32 represents a mind map of the key words/phrases used by the different respondents. These key words were then analysed to determine the relevant constructs and Table 18 and Figure 33 show the frequency count per construct. Figure 33 shows that the most common response to the phrase "equipment and services are easy to source locally" was the construct that supporting services are limited (frequency = 12). The second construct that a strong support industry exists had a frequency count of 4.

A respondent sector analysis of the different constructs in Table 19 and Figure 34 showed that government, industry, university, science council and venture capitalist respondents were of the opinion that the support service industry was limited.

Supporting and Related Industries

**Table 18: Rank order of the different constructs**

| Rank order | Construct | Frequency |
|---|---|---|
| **1** | Supporting services are limited | 12 |
| **2** | A strong support industry exists | 4 |

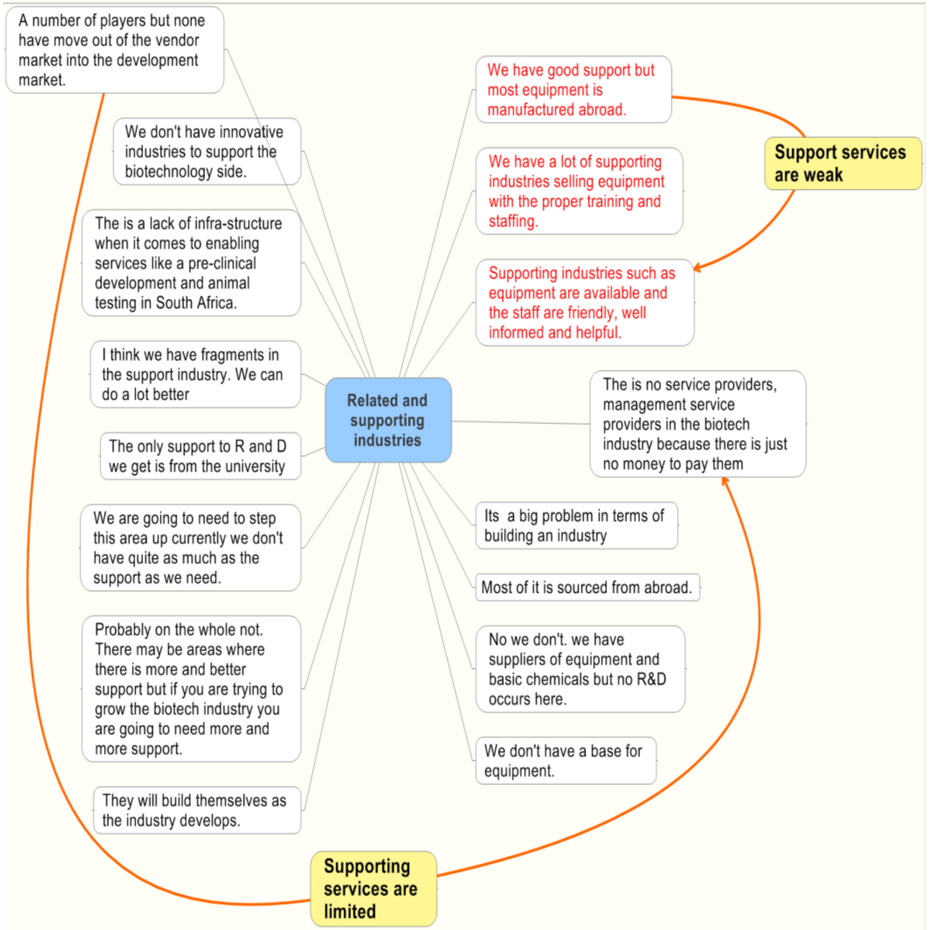


**Figure 32: Mind map of strategy success**

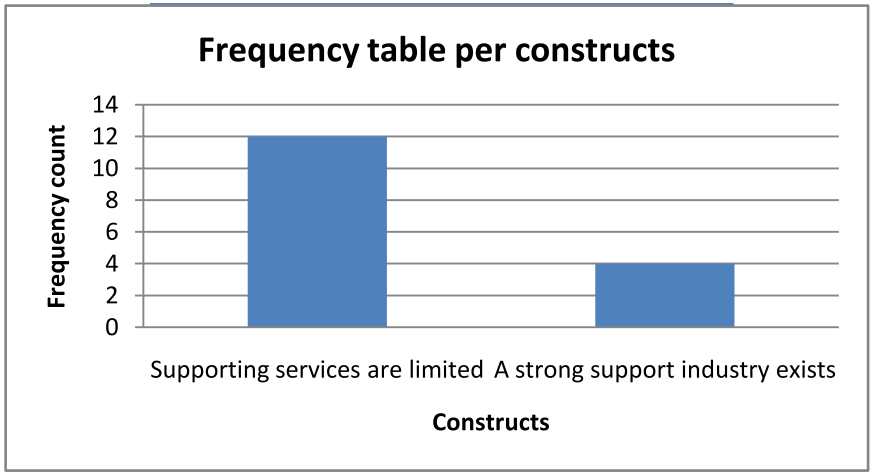


**Figure 33: Frequency table of the different constructs arising from the successfulness of South Africa's biotechnology sector**

**Table 19 Sector analysis of the different constructs**

| Sector Analysis | Construct | Frequency |
|---|---|---|
| **Government** | Supporting services are limited | 5 |
| | A strong support industry exists | 1 |
| **Industry** | Supporting services are limited | 2 |
| | A strong support industry exists | 1 |
| **Universities and Science Councils** | Supporting services are limited | 3 |
| | A strong support industry exists | 2 |
| **Venture Capitalists** | Supporting services are limited | 2 |
| | A strong support industry exists | 0 |

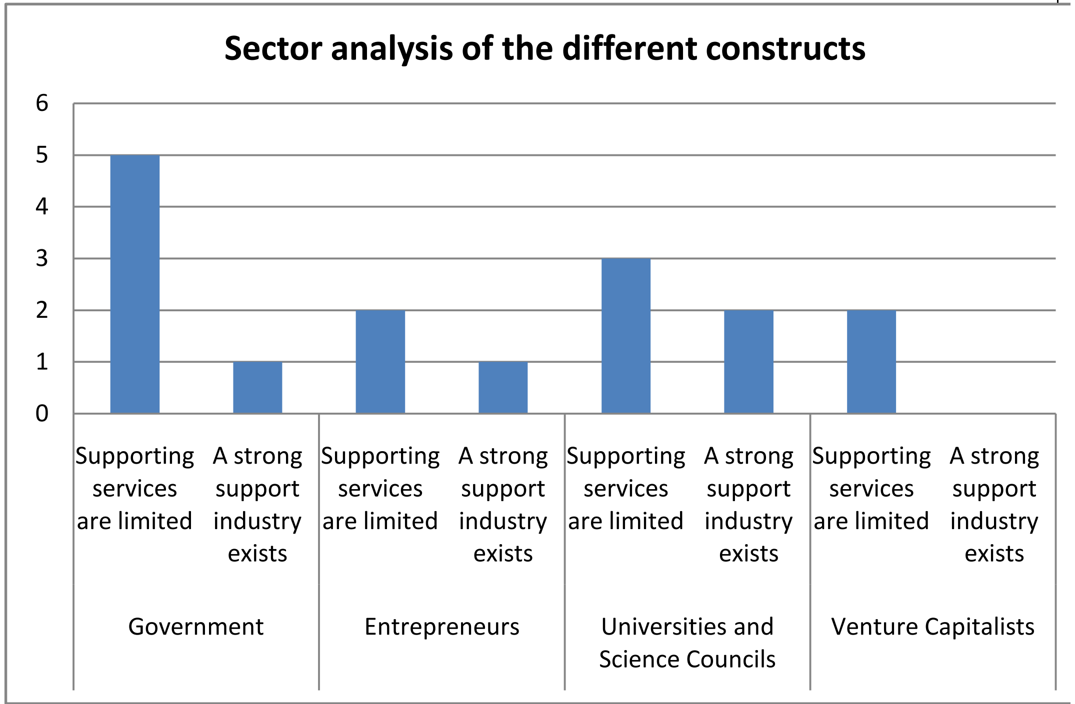


**Figure 34: Frequency table of the success of biotechnology per sector analysis**

#### *5.3.4.3 Summary of proposition 4 findings*

The major construct of the two discussion points are summarised in Table 20 below.

**Table 20: Summary of proposition 4 main findings**

| Sub-propositions | Main construct emerging |
|---|---|
| **Networking** | A strong network exists |
| **Local suppliers** | Supporting services are limited |

The discussion points around proposition 4 gave a mixed response. This shows that the respondents were of the opinion that there was a deficiency in related and supporting industries for biotechnology institutions or firms in South Africa.

### 5.3.5 Proposition 5

**<u>South African biotechnology institutions or firms have no interest in the establishment of a dedicated biotechnology science park</u>**

This section related the opinions of respondents to the statement “cluster formation will be an appropriate method in growing the sector” Figure 35 represents a mind map of three key words/phrases used by the different respondents. These key words were then analysed to determine the relevant constructs and Table 21 and Figure 36 show the frequency count per construct. Figure 36 shows that the most common response to the question was that cluster formation is supported (frequency = 6). Six respondents felt that the development of a cluster is not the correct approach.

A respondent sector analysis of the different constructs in Table 22 showed that government, industry, university and science council, and venture capitalist respondents were all of the majority opinion that cluster formation is the correct approach to developing the biotechnology sector.

## Cluster Formation

**Table 21 Rank order of the different constructs**

| *Rank order* | *Construct* | *Frequency* |
|---|---|---|
| **1** | Cluster formation is supported | 15 |
| **2** | Cluster formation is a unsuitable model | 4 |

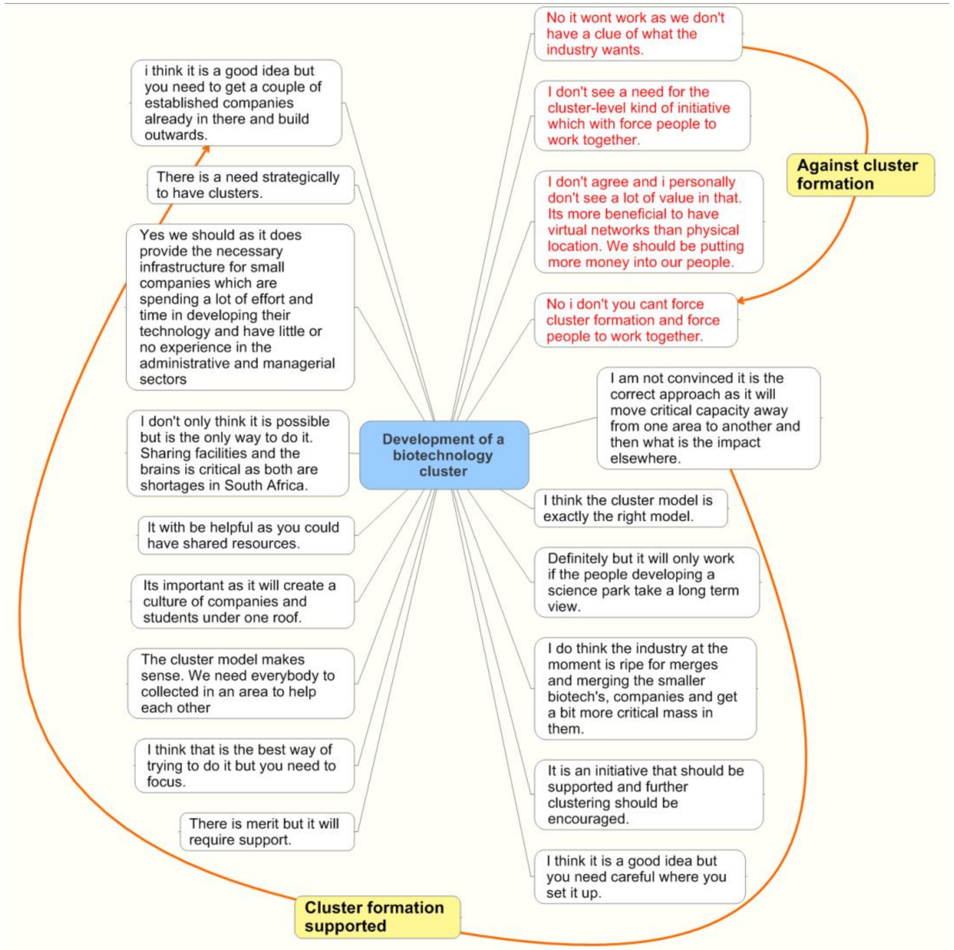


**Figure 35: Mind map of respondents' views on cluster formation as a method of growing the biotechnology sector**

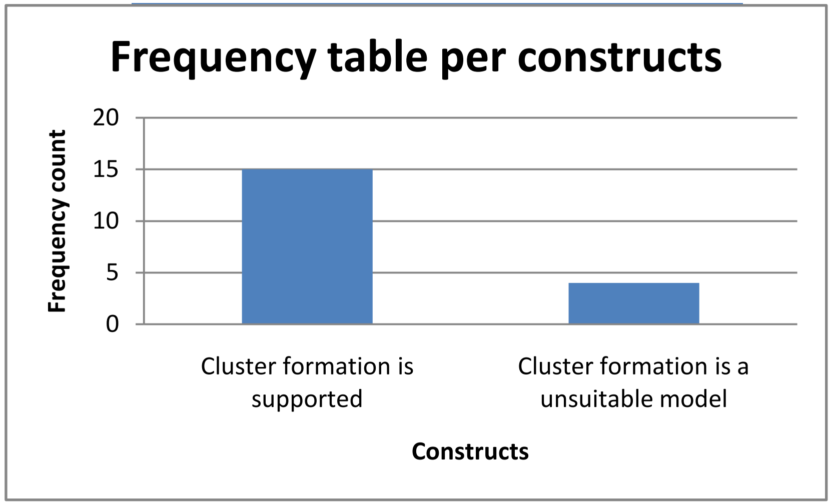


**Figure 36: Frequency table of the cluster formation within the biotechnology sector**

**Table 22: Sector analysis of the different constructs**

| Sector Analysis | Construct | Frequency |
|---|---|---|
| **Government** | Cluster formation is supported | 5 |
| | Cluster formation is an unsuitable model | 1 |
| **Industry** | Cluster formation is supported | 2 |
| | Cluster formation is a unsuitable model | 1 |
| **Universities and Science Councils** | Cluster formation is supported | 3 |
| | Cluster formation is an unsuitable model | 2 |
| **Venture Capitalists** | Cluster formation is supported | 2 |
| | Cluster formation is an unsuitable model | 0 |

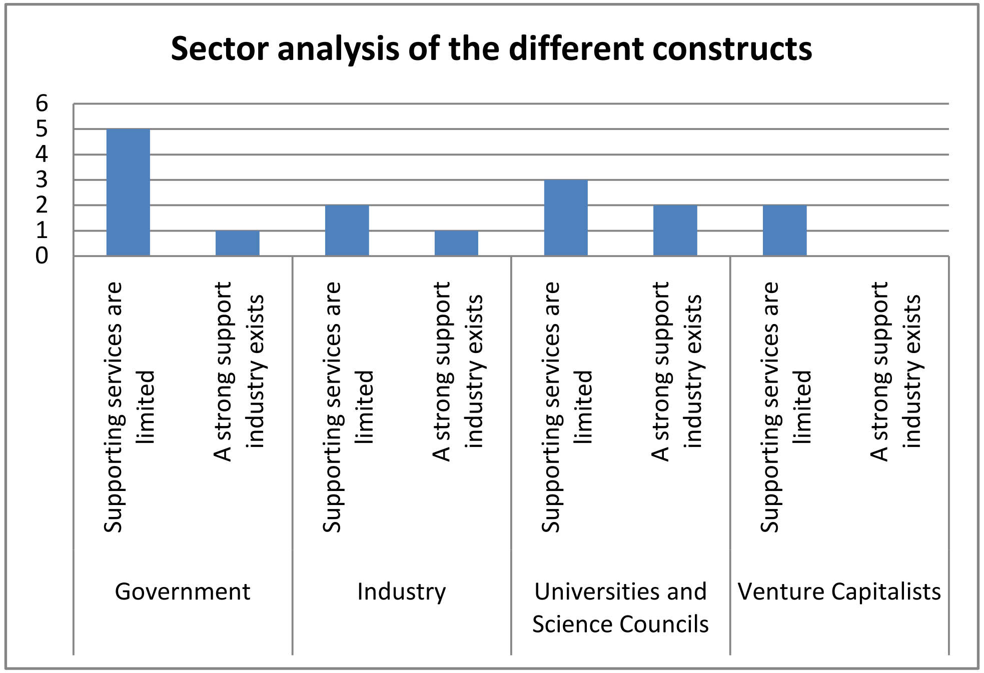


**Figure 37: Frequency table of the cluster formation within the biotechnology per sector analysis**

# Chapter 6 Research Discussion

This chapter provides insights into and interpretation of the findings highlighted in the previous chapter.

## 6.1 Introduction

This chapter analyses the results applied to Porter's Diamond framework and addresses the strengths and weaknesses of the biotechnology industry in South Africa that have been identified. The analysis is presented under the same headings as the previous chapter with each proposition and the research question being discussed separately.

## 6.2 Demographic data

Three sets of demographic variables were considered important for obtaining a good assessment of the biotechnology industry in South Africa.

The first demographic variable was sector analysis. The major role-players in the biotechnology sector were identified as government, industry and academia. An equally representative sample of the three groups of role-players was obtained and was considered important in view of the fact that the research focused on the competitiveness of a sector. A fourth important role-player group is the venture capitalists; however, within the biotechnology sector venture capitalists are extremely scarce and made up 10% of the respondents (Figure 8).

The second demographic variable was years involved in biotechnology. This variable is used to gather information relating to data validity. The results showed that the majority of the respondents had been involved in the biotechnology sector for a number of years, with 45% having more than 10 years' experience (Figure 9). This can be used as a potential test of data validity and reliability as the opinions and views were from respondents with many years of experience in and knowledge of the sector. A breakdown of the different sectors to determine if a particular sector had inexperienced personnel in senior positions found no evidence to suggest this to be the case.

The third demographic variable was position seniority. The data on this demographic variable was gathered to ensure that the respondents were experienced, knowledgeable about the current biotechnology strategy and were are able to view the sector holistically. Thirty-seven per cent of the respondents were at CEO level, with a further 32% at executive director level (Figure 10). The data obtained were therefore from respondents who understood the sector and the strategy. On the negative side the view of a wider section of the population within the sector could not be obtained.

## 6.3 Proposition 1

**Factor conditions are a problem for South African biotechnology institutions or firms**

As discussed in Chapter 2, Porter (1990b) states that nations succeed in industries where they are particular good at factor creation. Factor conditions are skills, capital and physical infrastructure levels within the sector. The results (Figures 11-19, Tables 2-8) indicated that this attribute of the Porter Diamond model was weak in South Africa's biotechnology sector. Skills, capital and infrastructure were the variables used to determine this attribute and all three variables were shown to be lacking within the industry.

### 6.3.1 Skills

*Main Construct: Critical shortage of skilled workers within the sector.*

The most frequently cited response (Tables 2-3 and Figures 11-13) was a critical shortage of skilled workers within the sector. The respondents were of the opinion that there were good technical skill levels, and stated that the skill requirement was for individuals with science-business cross-over skills. Comments of respondents were:

*"Students are well prepared technically but lack an understanding of business."*
*"It is easy to find people generally leaving academic institutes but people with an understanding of science and biotechnology who have worked in biotechnology are few and far between."*

Most science graduates appear to have a limited understanding of business, or possibly a lack of entrepreneurial skills, particularly risky entrepreneurial business, which is characteristic of successful biotechnology companies.

On the other hand, local universities have good business schools which are currently addressing the business learning needs of managers at all levels and from all disciplines; however, no courses addressing the business side of science are available. The introduction of specially tailored short-term or modular courses aimed specifically at imparting business skills to innovative scientists would benefit not just the biotechnology sector but also the wider science community (Smith *et al.*, 2005).

Respondents also felt that the sector was losing skills to the international market. Graduates do not have many job opportunities as there are limited private sector employers within the sector. This forces people either to go overseas or to find employment outside the sector. Those who go outside the sector are paid a higher salary and do not return.

*"It is difficult because the salaries are not internationally competitive."*

The sector analysis data (Table 3 and Figure 13) show that the majority of respondents from the different sectors agreed that there was a critical mass shortage of skilled biotechnology workers.

### 6.3.2 Capital

*Main Construct: Government funding is available but is not being optimally utilised*

The most frequently response (Tables 4 and Figures 14 and 15) was that sufficient government funding was available but was not being optimally utilised. The respondents were of the opinion that the BRICs and the innovation funds were too regulatory and were hampering the progress of the sector. Their overhead cost structure was extraordinarily high with limited research project funding. The respondents felt that the BRICs had spent money needlessly in creating platforms but should have rather focused on the creation of new companies, spinning off new companies from universities and science councils, instead of funding university-based projects. The respondents were of the overwhelming view that the funding agencies should not be 'socialist' organisations but should strategically fund fewer projects with larger investments into these projects up to the point of commercialisation. Comments of the respondents were:

*"Biotechnology funding is difficult as biotechnology by its nature is high risk and government has not properly identified strategic areas to fund."*

*"Almost impossible if you don't make friends."*

*"The BRICs have gone to fund early-stage research instead of handling the commercial side required to stimulate research."*

The respondents were also of the opinion that venture capitalists were not attracted to funding biotechnology, as a venture capitalist culture did not exist in South Africa. Moreover, the venture capital industry expects 200-300% return on its investment within a short period of time (2-3 years), and such returns are unlikely within the biotechnology industry. The returns on the development of a biotechnology product could take longer than 10 years and venture capitalists are not prepared to invest over such a long period of time.

There is a disparity of thinking between the biotechnology sector and the venture capitalist industry in that biotechnology is a high-risk sector with high infrastructure set-up costs in comparison to other sectors such has IT. Venture capital funds in general are tough to find in South Africa and venture capitalists would rather invest in resources where return on investment is over a much shorter period. According to Garelli (2003) competitiveness cube model nations manage their competitiveness by being attract through incentives and direct investment. The lack of investment from the venture capitalists and private sector indicates that South Africa is not seen as an attractive location currently for biotechnology investment

The sector analysis data (Table 5 and Figure 16) showed that the science councils and universities were the most critical of the different public sector funding agencies, and the majority were of the opinion that the funding was not being optimally utilised. Some of the comments were:

"*Funding chasm.*"

"I*t is difficult to get sufficient funding. We get bits and pieces but to get full-fledged projects funded is impossible.*"

The entrepreneurs were equally critically of the current funding environment with one respondent being of the opinion that in order to further grow the sector one should consider firing all the BRICs' CEOs because this bureaucratic strategy is hindering the sector's growth.

In summary, research funding is provided in sub-optimal amounts. An insufficient amount of funding is available for research work to be conducted. The development phase seems to be neglected with minimal pre-proof of concepts and seed funding available, while at the same time insufficient funding is available to get biotechnology research to the point of commercialisation. The funding mechanism is also cumbersome, difficult and inefficient, with long turn-around times cited as a major problem. There was confusion among the respondents about the roles of innovation and the BRIC funding agency as it was felt both are occupying the same space in the value chain.

### 6.3.3 Physical infrastructure

*Main construct: Insufficient physical infrastructure available within the sector.*

The most frequently cited response (Tables 7 and Figures 17 and 18) was that insufficient physical infrastructure is available within the sector. The majority of respondents (Figure 18) were of the opinion that the sector does not have the necessary infrastructure required to build and develop. There is a lack of manufacturing capabilities within the sector. There is dearth of good R&D facilities and many start-up companies do not have the R&D facilities that will provide them with an advantage over their competitors. Biotechnology is a R&D-intensive sector, and not having the basic requirements for a company to build is a serious hindrance to the and sector. According to Porter's demand model the better the infrastructure, the better the available competition becomes (Porter, 1998a, Porter, 1999, Porter, 1990a). A secondary effect of having good infrastructure is that skilled workers are attracted to places which have good infrastructure.

A sector comparison analysis (Table 8 and Figure 19) showed that government respondents felt there was a shortage of infrastructure within the sector, but the respondents from the universities and science councils felt that there was sufficient equipment within the sector. This possibly indicates that universities and science councils over the years have build a good level of equipment for research activities, but that this equipment is not accessible to people outside these organisations. This was the view also shared by the industry respondents, many of whom were in the start-up phase of their business:

"*Science councils and universities who do have some of the equipment are not commercially oriented.*"

In summary, physical infrastructure was found to be lacking within the sector. One of the primary barriers that the sector faces is the lack of access to sophisticated laboratory facilities that could easily be leveraged to assist large firms with the necessary shared infrastructure. Support facilities, incubators, premises with wet labs and flexible leasing arrangements are almost non-existent. Sharing of equipment and technologies is a big problem, and there is a need for more optimal leveraging of available infrastructure and available laboratory facilities (Smith *et al.*, 2005). The facilities and equipment used by industry, the science councils and the private sector are fairly redundant, but due to non-collaboration such equipment and facilities are not used to capacity, and in most cases are used only a few days a week.

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| **Summary of Proposition 1** |
| --- |
| Science-business cross-over skills are desperately needed in the sector. While business training for scientists may help alleviate this problem, most respondents felt that the biggest benefit would come from recruiting scientists who have started and run their own business, preferably in biotechnology. Locally this type of skill is almost non-existent.<br><br>Research funding is provided in sub-optimal amounts. An insufficient amount of funding is available for research work to be conducted. The development phase seems to be neglected with minimal pre-proof of concepts and seed funding available while at the same time insufficient funding to get biotechnology research to the point of commercialisation is available. Secondly, funding is cumbersome, difficult and inefficient with long turn-around times cited as being a major problem on the part of government. |

One of the primary barriers that the sector faces is the lack of access to sophisticated laboratory facilities that could easily be leveraged to assist large firms with the necessary, shared infrastructure and support facilities. Incubators, premises with wet labs and flexible leasing arrangements are almost non-existent. Sharing of equipment and technologies is a big problem and there is a need for more optimal leveraging of available infrastructure and available laboratory facilities.

Based on the above findings from the responses of the interviewees, the proposition that *factor conditions are a problem for South African biotechnology institutions or firms* is true.

## 6.4 Proposition 2

**<u>Demand conditions within the South African biotechnology sector are poorly developed</u>**

As discussed in Chapter 2, Porter (1990b) states that nations succeed in industries where they are particular good at demand conditions. Demand conditions are:

- The needs of the local consumer of biotechnology
- The size and pattern of growth opportunities in the market for biotechnology
- The mechanism through which a nation’s domestic preference for biotechnology can be transferred to foreign markets.

The results (Tables 9-12and Figures 20-25) show that this attribute of the Porter Diamond model is weak in South Africa’s biotechnology sector. Public understanding and customer preferences were the two variables used to assess this attribute and both were found to be weak within the industry.

### 6.4.1 Public understanding

*Main construct: Public understanding is poor*

The most frequent response (Tables 11 and Figures 23 and 24) was that public understanding of biotechnology was poor. The majority of the respondents (Figure 24) were of the opinion the sector was not at understood by the majority of people. Comments were:

"*No I don't think the public at large understands biotechnology.*"

*"Public understanding is poor."*

The Department of Science and Technology has established a biotechnology centre to handle the publicity surrounding biotechnology called Public Understanding of Biotechnology (PUB). This body has a mandate to communicate on the issues surrounding biotechnology in an unbiased manner. However, the study found that the majority of respondents did not have an understanding of biotechnology and that PUB has failed create an understanding of biotechnology. Comments on PUB were:

"*I think PUB has been a massive failure in stimulating interest in biotechnology in the country.*"

*I don't know what PUB has been doing."*

"*I have never heard of PUB*"

PUB is unfocused and partially as a consequence of this the demand for customised local products has been minimal.

One might argue that public understanding is unimportant as it is not normally a factor to be considered in obtaining funding, and it should be left to the relevant funding agencies to identify potential strategic areas to fund. However, one needs to ensure that the sector is not just drawn by a science push strategy but also by market push, and this can only be achieved if the public has some understanding of the sector.

In terms of the sector analysis is was found (Table 12 and Figure 25) that government was of the opinion that the public had a good understanding. This view is extremely short sighted and can be seen as government believing that PUB has been successful and not believing its shortcomings and failure.

#### 6.4.2 Customer focus

*Main construct: Customer focus is the international market*

The most frequent response to this variable (Tables 9 and Figures 20 and 21) was that respondents were focusing on the international customer market. The majority of respondents (Figure 21) were of the opinion that locally the sector did not have economies of scale nor would there be sufficient returns on their investment. Comments were:

"*IF we are only doing research for the local market, then research will never give any return on investment."*

*"For most biotechnology products to have a significant base, it would have to have an international market.*"

*"The customers are the international market."*

Porter (1990a) view of customer understanding within a sector is a sophisticated sector that is able to understand the technology and have unusual needs in the industry that are significant. One would then one have good demand conditions. However, this was found not to be the case in the South African biotechnology sectors as there is more of an international market focus. This indicates a potential serious weakness in local demand.

The needs of the local customer are currently being neglected as the public has no or limited understanding of biotechnology. Moreover, the view of the respondents was that local consumers had limited purchasing power, and that economies of scale did not exist locally, hence the international focus.

What is evident here is that the R&D for developing new products is not being led by the South African consumers and public, and instead the international trends are used as the standard for customer needs. This approach does not give the sector or the country a competitive advantage as the companies/science councils are too far away from their customer base in the USA and Europe, and will continue to find it difficult to break into the sector market. These stakeholders need to become locally focused first and then internationally focused. A successful example is Sasol, who initially developed technology for the local market and then only more recently became a global role player.

| **Summary of Proposition 2** |
| --- |
| The results of this study show that the majority of respondents considered there to be a poor understanding of biotechnology by the general public in South Africa.<br><br>There is no sophisticated local buying market, with local demand almost non-existent and the majority of the respondents focusing on the international market.<br><br>Based on the above findings from the responses from the interviewees, the proposition that *demand conditions within the South African biotechnology sector are poorly developed* is true. |

## 6.5 Proposition 3

**Firm rivalry is poorly developed in the South African biotechnology industry**

*Main construct: Local competition is weak, the focus is on international competitors*

The most frequent response (Tables 14 and Figures 26 and 27) was that respondents were focusing on international competitors as no local competitors existed. The majority of respondents (Figure 26) were of the opinion that locally the sector did not have economies of scales nor would there be sufficient returns on their investments. Figure 27 shows that an overwhelming majority of the respondents felt that there were no local competitors.. Comments were:

"*We have a fairly immature system therefore you can't expect competition*."

"*South Africa's industry steeped in biotechnology is very small*."

*"I think the sector is non-existent so there is no competition and if there was it would come from international competitors*."

The dynamism and pressure created by vibrant local rivalry is perhaps the most important stimulus to creation, innovation and value adding in an industry (Porter, 1990a, Porter, 1998a). This rivalry, coupled with a growth or product excellence strategy of companies can enhance and grow, facilitating company growth and ultimately sector growth. Issues relating to local and international competitors were addressed. Rivalry has a powerfully stimulating effect on the other attributes (Porter, 1998b). A report compiled in 2007 to investigate the number of companies in biotechnology has found there are 78 active companies and 38 core biotechnology companies in the South Africa (Pouris, 2007). This is too small a number of core companies in the country for true rivalry to develop within the different specialisation areas of biotechnology.

All the respondents felt that competition came from the international companies abroad and their focus was international competitors instead of local competitors. The sector analysis data (Table 15 and Figure 28) indicated that an overwhelming majority of the respondents across the different sectors believed there to be no local competitors.

| **Summary of Proposition 3** |
|---|
| The findings support the proposition that *firm rivalry is poorly developed in the South African biotechnology industry*. |

## 6.6 Proposition 4

**<u>There is a deficiency in related and supporting industries for biotechnology institutions or firms in South Africa</u>**

The biotechnology industry is a highly specialised industry requiring highly specialised supporting industries. This proposition explores the existence of networks within the sector and also whether supporting industries to biotechnology exist in the country.

### 6.6.1 Networking

*Main construct: A strong network exists within the industry.*

The most frequent response (Table 16 and Figures 29 and 30) was that a strong network existed. The majority of respondents (Figure 30) were of the opinion that there was a strong network within the field and was growing. This is perhaps not surprising given the small size of the sector. The BRICs have done extremely well in networking and creating opportunities with institutes abroad. Comments were:

"*The network is very strong and we are an intimate part of the group"*

"*A strong network exists*."

"*There is a networking culture developing.*"

(Mulder and Henschel, 2003) identified the sector as being fragmented in 2003; however; based on the responses of the respondents this has changed with a close although fairly small network existing. Events such as the Bio2Buz is a conference focusing on issues in biotechnology which has become an annual event and is fairly well supported. BioSA is a organisation that has been recently formed and focuses on bringing the different role-players together.

However, a criticism is that although a network exists between various institutes, this network has not in many instances grown to the level where joint collaborative projects, etc. are funded together.

The creation of networks is an important component in building competitiveness within a sector and an industry, and over the last few years networks within the sector have developed but in many instances are still in their infancy. These networks will need to grow and develop in the next few years to make the sector much more competitive than it currently is.

### 6.6.2 Local suppliers

*Main construct: Supporting services are limited*

The most frequent response (Tables 18 and Figures 32 and 33) was that supporting services to biotechnology were limited. Comments were:

*"There are a number of players but none have moved out of the vendor market to the development market."*

*"We don't have innovative industries to support the biotechnology side."*
*"We are going to have to step this area up as currently we don't have as much support as we need."*

The research found that there were limited supporting services in the country. The majority of R&D activities relating to this sector are done outside the country. South Africa is seen only has a distribution centre of equipment and services. This view has created deficiencies with the sector:

- Long delay times from time of purchase to the point of operation.
- Support services: when instruments require repair this can take a long time as in many cases a specialist technician from abroad is required. This affects instrument down-time and the cost of repair is much higher in comparison to the US and Europe where specialised support industries exist.
- The impact of the technology advancement made by the different supporting services is not initially felt here and it normally take a few months to a years to be adopted. The biotechnology sector in South Africa then becomes a late mover in technology advancement and not a early adopter.

| **Summary of Proposition 4** |
|---|
| The study found that although a strong network exists, it is still in its infancy stage within the biotechnology industry.<br>There is a lack of support services to biotechnology in the country, and it is currently seen as mainly a distribution centre and not as a R&D centre.<br>Based on the findings from the respondents the proposition that *there is a deficiency in related and supporting industries for biotechnology institutions or firms in South Africa* is true. |

## 6.7 Proposition 5

**South African biotechnology institutions or firms have no interest in the establishment of a dedicated biotechnology science park**

*Main construct: Cluster formation is supported*

The most frequent response (Tables 21 and Figures 35 and 36) was that the formation of a cluster is supported. The majority of respondents felt that cluster formation was essential to growing and developing a biotechnology sector. Many respondents were of the opinion that the formation of cluster approach was the only way forward to develop the sector: Comments expressed were:

"*I don't think it is possible but it is the only way to do it. Sharing facilities and the brains is critical as there are shortages of both in South Africa."*

*"There is a need strategically to have clusters."*

*"Definitely, but it will only work if people developing a science park take a long-term view."*

*"The cluster model makes sense. We need everybody to be collected in an areas help each other out."*

The current DST strategy of creating geographic clustering in the four regions where the BRICs are located, although noteworthy, has not appropriately created and stimulated an industry in any single geographic location. Instead, it has funded similar projects in the different regions without the existence of critical mass and many of these projects have not created significant added value.

Clustering has in the past played a important role in building and creating critical mass within a region in biotechnology (Smith *et al.*, 2005, Wolson, 2005). This has enabled concentration not only of the biotechnology companies but also suppliers and other supporting industries.

Those respondents who were critical of the clustering concept were of the opinion that it is extremely difficult to force people to work together using such an approach, and that one has to be extremely careful about deciding what clusters are created in which geographical areas, as people may not be willing to re-locate.

| **Summary of Proposition 5** |
| --- |
| The results did not support this proposition. The majority of respondents were in favour of setting up biotechnology clusters. |

## 6.8 Summary of Findings

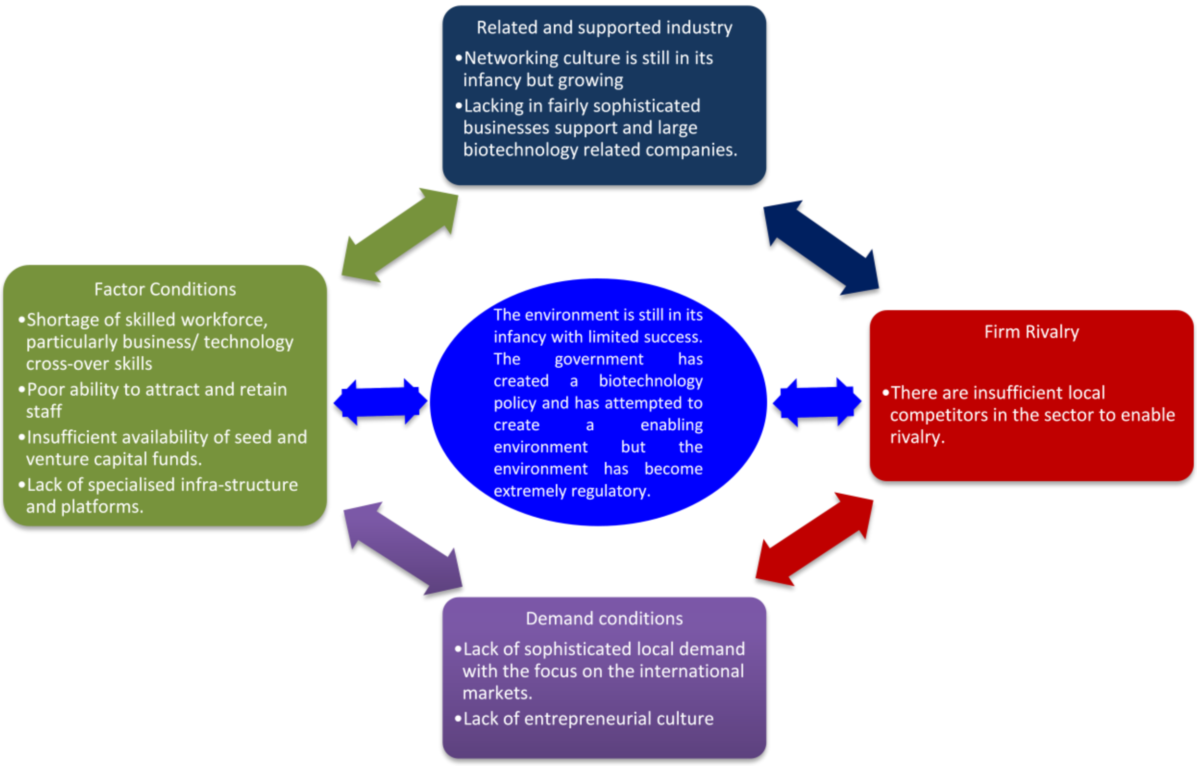



**Figure 38: Summary of proposition findings drawn on Porter's Diamond model**

**Table 23: Summary of proposition findings**

| Proposition | Capability Level | Summary of major gaps |
|---|---|---|
| Factor conditions (skills, capital, and infrastructure) are a problem for South African biotechnology institutions or firms. | Average | • Shortage of skilled workforce, particularly business/technology cross-over skills<br>• Poor ability to attract and retain staff<br>• Insufficient availability of seed and venture capital funds<br>• Lack of specialised infrastructure and platforms |
| Demand conditions (customer needs, market size) within the South African biotechnology sector are poorly developed. | Below average | • Lack of sophisticated local demand with the focus on the international markets<br>• Lack of entrepreneurial culture |
| Firm rivalry is poorly developed in the South African biotechnology industry | Below average | • There are insufficient local competitors in the sector to enable rivalry |
| There is a deficiency in related and supporting industries for biotechnology institutions or firms in South Africa | Below average | • Lacking in fairly sophisticated businesses support and large biotechnology-related companies |
| South African biotechnology institutions or firms have no interest in the establishment of a dedicated biotechnology science park | Average | • Cluster awareness and culture is at an infancy stage |

The research has shown that the South African biotechnology industry is weak in all attributes of Porter's Diamond of National Competitiveness and is still in its infancy (summary in Figure 38 and Table 23). These findings are similar to those found by Donninger (2006) in which all attributes were found to be weak.

**Factor conditions**

Science-business cross-over skills are desperately needed in the sector. While business training for scientists may help alleviate this problem, most respondents felt that the biggest benefit would come from recruiting scientists who have started and run their own business, preferably in biotechnology. Locally this type of skill is almost non-existent.

Research funding is provided in sub-optimal amounts. An insufficient amount of funding is available for research work to be conducted. The development phase seems to be neglected with minimal pre-proof of concepts and seed funding available, while at the same time insufficient funding is available to get biotechnology research to the point of commercialisation. Moreover, funding by government is cumbersome, difficult and inefficient, with long turn-around times cited as being a major problem.

One of the primary barriers that the sector faces is the lack of access to sophisticated laboratory facilities that could easily be leveraged to promote large firms with the necessary, shared infrastructure and support facilities (Smith *et al.*, 2005). Incubators, premises with wet labs and flexible leasing arrangements are almost non-existent. Sharing of equipment and technologies is a big problem and there is a need for more optimal leveraging of available infrastructure and available laboratory facilities. These are all critical input factors that needs to be addressed urgently.

**Demand conditions**

Understanding of biotechnology in South Africa among the general population is poor. The creation of the PUB programme has not made an impact overall on improving the public's understanding. The impression of the various respondents was that local customers were not sophisticated and the focus was on international customers. This is extremely short sighted as HIV, TB and malaria are life-threatening diseases in Africa and not in Europe and the US. It is of great concern that there was a general disregard of market factors among the respondents.

**Firm rivalry**

Porter argues that this is the most critical driver of competitiveness. The local biotechnology sector is small and limited. Local rivalry does not appear to be a significant feature of the industry.

The creation of a dedicated science park and biotechnology clusters could create and stimulate rivalry between companies and thus advance biotechnology. An overwhelming majority of the respondents agreed that the creation of biotechnology clusters was essential to growing the industry.

**Related and supporting industries**

The study found that although a strong network exists it is still in its infancy stage in the biotechnology industry and has not grown to the point of joint collaborative projects.

Many life science material suppliers do have agencies in South Africa, but almost all materials are still sourced from overseas and the local offices are mainly distribution centres. This creates problems such as delayed delivery of materials, exchange control fluctuations and a delay in accessing and understanding the latest technological advancements and developments in the field. These aspects will not change until economies of scale in biotechnology are achieved locally to force supporting industries to bridge the gap that will be created.

**The role of government**

The South African government made an important decision to invest in biotechnology and developed a biotechnology strategy however the implementation of the strategy has not had the desired impact and according to the analysis done using Porter Model of Competitiveness we find that the sector is weak in all four attributes of the model. However the return on investment of sector can not completely be judged over the last sevens as we still in the infancy of the sector and a longer time frame is needed.

Some nations support competitiveness more than others by creating an environment which facilities the competitiveness of enterprises and encourages long term sustainability (Garelli, 2003). The government should continue to invest in the sector to enable long term sustainability however it needs to be aware that through its policies and approaches it can hinder the sector. A number of respondents felt that there is a number of bureaucratic hurdles to overcome within the government structures, turnaround time of project funding can take up more than a year before decisions are made, this is unacceptable, governments funding currently is in the form of equity in the new enterprise which is acceptable but government should not take an hands on approach in trying to run the firm as it potential scares away entrepreneurs and potential investors.

# Chapter 7 Recommendations and Conclusions

This chapter presents the findings of the study and makes recommendations to policy makers, academics and industry stakeholders.

## 7.1 Main Findings

South Africa's nascent biotechnology industry is stumbling at every stage along the value chain, from laboratory bench to factory gate. A handful of first-class scientists vie for limited government funding, few of them have the expertise to commercialise their ideas, and domestic private capitalists have yet to be convinced that there is money to be made in the sector.

Over the last ten years, the South African government has actively promoted research and development in human health through an extensive series of funding and investment programmes. The National Biotechnology Strategy was one such programme. An ambitious plan was devised that aimed to use research, development and technology transfer to address strategic priories in health and development, and the Internet for training and capacity building in health sciences. However after investments of close to R700 million, South Africa failed to produce what could be called tangible results in the form of patentable medicines, commercial products and licence agreements, nor did the research activity make South Africa an attractive location for multinationals to relocate to conduct research activities.

Some of the key shortages are entrepreneurial spirit in the research community, the lack of concentration of knowledge workers, a shortage of funding for sustaining new business projects created in medium and long-term R&D programmes, and cooperation between scientists and technologists is still in its infancy.

## 7.2 Skills

The biotechnology skill sets are highly specialised, and require a combination of science and business skills. South Africa has a good history of producing world-class researchers and good business leaders, but the hybridisation of science and business skills is lacking in the sector. The skills required for research and business are both different, with neither being more important. The South African biotechnology industry needs both skill sets to become successful.

The sector is losing a number of highly skilled graduates to the overseas market as there are insufficient job opportunities in the country. Similarly, those skills that are developed are lost to other sectors of the economy as the remuneration structure of researcher workers is extremely low in comparison to that of other sectors

### 7.2.1 Recommendations regarding skills

Investment should be made into developing tailored business-specific courses for biotechnology workers aimed at specifically imparting business skills. Switzerland has created MBA programmes specifically for the pharmaceutical industry. Similar programmes should be developed locally, not only for the biotechnology sector but for the general research sector. A combination of business and technical skills will change the culture of the sector and will stimulate entrepreneurship. This should not only occur at the post-graduate level but should be introduced into undergraduate curricula.

Experienced South African and foreign biotechnology practitioners currently working abroad should be identified and enticed to return or come to South Africa. Both foreign and South African experts can be attracted through partial tax incentives and through the creation of residency programmes which allows experienced executives to live in South Africa to assist start-ups and to mentor junior executives. The attraction of innovative scientists would benefit not just the biotechnology sector, but also the wider science community. The existing science courses can also be enhanced by involving international experts on the curriculum course panels.

Government should give consideration to creating a biotechnology institute as an enabling tool to allow graduates to complete an apprenticeship programme. Such an institute would be able to impart both the business and technical skills required, and could ideally be created within a science park to allow different skills to be learnt.

The salary structure of knowledge workers should be re-evaluated to ensure that scientists are receive adequate remuneration which is in line with offers received from outside sectors.

## 7.3 Funding

South Africa should continue its investment in biotechnology. Funding was a major deficiency identified by most of the respondents. The lack of strategic investment was highlighted as a major failing of the current system, together with bureaucratic hurdles in obtaining funding. Venture capitalists have not been persuaded by the local biotechnology sector and have not significantly invested in the sector. Venture capitalists will not enter the sector until significant gains can be seen in terms of commercialisation of products or multi-million rand licence agreements. Government will have to continue being the major funding source driving the sector.

### 7.3.1 Recommendations regarding funding

Funding should be focused on programmes that leverage South Africa's unique competencies in areas such as biodiversity, virology and possible tropical diseases, and funding needs to move away from being a socialist activity. Funding should focus on supporting a few projects from development to commercialisation. The focus should be on distinct elements of the value chain, with the ability to extract value by working on part of the pharmaceutical value chain. The following could be potential be areas of investment (Smith *et al.*, 2005):

- Partially develop and licence novel and new chemical entities to address the key heath issues facing South Africa and develop nations by systematically creating an extensive medicinal compound library of South Africa's rich biodiversity.
- Develop and manufacture novel, cost-effective, easy-to-use, point-of-care diagnostics for major developing world issues.
- Develop niche market therapeutics with affordable drug delivery platforms and generic activities to improve the effectiveness of treatments for developed and developing world diseases of relevance to South Africa.

Government's policy of owning equity in the companies needs to be re-evaluated as this could potentially be a deterrent to outside investors.

The process of obtaining funding needs to be significantly shortened as turn-around times can be longer than a year. Within this time research ideas and concepts can become redundant and significant competitive advantages can be lost if funding is not provided early.

## 7.4 Understanding Biotechnology

Biotechnology is about the commercialisation of products, and without a clear understanding of biotechnology it will be extremely hard for biotechnology to survive locally. This study found that the understanding of biotechnology was minimal, and that the Public Understanding of Biotechnology office of the DST has had limited success in improving the level of understanding.

### 7.4.1 Recommendations regarding understanding of biotechnology

The science councils, universities and the private sector should be promoting biotechnology among the public. Universities have access to thousands of students and are best positioned to stimulate industry interest. The holding of workshops together with the science councils and the private sector would dramatically stimulate the sector.

The PUB is an important office of the government, but is possibly located in the wrong government department, and moving it to higher education should be given consideration as many of the products developed will affect younger people and getting their understanding from a young age is important.

## 7.5 Networking

Networking was found to be in the embryonic stage in the sector. Many of the respondents felt that due to the small size a strong network exists, but it is only now that organisations such as BioSA are being created to bring together the different stakeholders in biotechnology.

Partnerships between the science councils, universities and the private sector are lacking as the physical infrastructure available at universities and science councils were hard to access.

Networking is not only limited to biotechnology companies but also across government departments, and between government departments has been seriously lacking. The Department of Science and Technology (responsible for driving the strategy) and the Department of Trade and Industry (responsible for the creation of small and medium enterprises) are as far apart on the way biotechnology should be implemented as the physical distance between the two departments.

### 7.5.1 Recommendations regarding networking

There should be an aggressive attempt to develop a tripartite relationship between government, industry and academia. Alliances should be formed between biotechnology companies and large pharmaceutical companies, so that when the latter accepts that a biotechnology company has discovered something worthwhile it will be prepared to make substantial milestone payments for its development.

The Departments of Science and Technology and Trade and Industry should together discuss and drive the biotechnology sector. A common agreed-upon strategy needs to be developed, as without the support of both departments the sector development will fail.

## 7.6 Cluster Development

The majority of respondents felt that cluster development is an important consideration in going forward as there are skills, infrastructure and equipment shortages within the sector. However, careful consideration should be given in which regions clusters are created.

### 7.6.1 Recommendations regarding clustering

Strategic clustering should occur with clusters established close to universities and science councils involved in biotechnology. This will enable collaboration and avoid duplication, and will enable fast tracking of research with more optimised leveraging of available infrastructure and laboratory facilities. The government should fund the establishment of such clusters. Each cluster should contain:

- A BRIC as the major funding agency.
- An independent Technology Transfer Office/'one-stop shop' for start-ups offering services such as business, legal and IP support.
- An international business development office. This office will oversee international collaboration and encourage international investment in local companies. For example, it will facilitate involvement in large, global infectious disease projects.

Clustering will enable skills and infrastructure shortages to be overcome. It will assist in the development of a training institute that bridges the gap between the technical skills and business skills required, and will potentially create an entrepreneurial culture within the sector.

## 7.7 Future Research

The purpose of completing a qualitative assessment is to use the analysis as a basis for future research. Future research should focus on:

1. A quantitative study of the sector using Porter's model.
2. A quantitative study to identify the number of companies formed from 2001 to the present and to assess the financial sustainability of these companies, the number of employees, etc.
3. Participants at all levels involved in biotechnology.
4. Participants from more regions of the country as the present study was focused predominantly on respondents in Gauteng.

The findings of this study have identified a number of potential areas of research:

1. Skills shortages were identified as a deficiency. A more detailed study of the particular skills in short supply could be conducted to identify potential skills not

currently being developed in the country. Such a study will be beneficial to universities in developing their curriculum for biotechnology students. Such a study could be conducted in the form of a questionnaire or by interviewing industry and science councils.

2. Funding was identified as a deficiency. A study conducted to identify strategic funding areas based on our current skills levels will be helpful. Secondly, a study should be done to understand the regulatory hurdles faced in obtaining funding. A study to understand the reason for limited funding from the private sector will prove extremely useful to stakeholders in the sector. All three studies can be performed through a questionnaire or interviews, but conducting a focus group with the different rile players will be useful.

## 7.8 Conclusion

South Africa has already made a start on the road towards effectively harnessing and developing its bio-economy. The bio-economy is in its infancy stage, and many deficiencies were identified and highlighted using Porter’s Diamond Model of National Competitiveness. The challenges facing the industry are great but not insurmountable. The challenge now is to be flexible enough to adapt to the bumps and potholes in the road and to mould our strategy to make it more effective.

# References

Akermann, B. and Kermani, F. (2006) The development of the South African biotech sector. *Journal of Commercial Biotechnology,* 12**,** 111-119.

Amit, R. and Schoemaker, P. (1993) Strategic assets and organizational rent. *Strategic Management Journal,* 14**,** 33-46.

Calantone, R., Vickery, S. and Dröge, C. (1995) Business Performance and Strategic New Product Development Activities: An Empirical Investigation. *Journal of Product Innovation Management,* 12**,** 214-223.

Campbell, K. (2007) In *Martin Creamer's Engineering News.*, Vol. 2, pp. 7-12.

Cloete, T. E., (2003) Biotechnology - The next wave. Available from:http://www.scienceinafrica.co.za/2003/may/biotech.htm (accessed 20 May 2008).

Cloete, T. E., Nel, L. H. and Theron, J. (2006) Biotechnology in South Africa. *Trends in Biotechnology,* 24**,** 557-562.

Donninger, R. (2006) *South Africa's Strategy for developing its Biotechnology industry by establishing biotechnology regional innovation centres (BRICs)*. MBA thesis, University of Pretoria.

DST (2007) Department of Science and Technology *Innovation towards a knowledge-based economy-Ten year Plan for South Afirca 2008-2018*. Pretoria.

Fári, M. and Kralovánszky, U. (2006) The founding father of biotechnology: Solving the Ereky enigma. *International Journal of Horticultural Science,* 12**,** 9-12.

Ferrer, M., Thorsteinsdottir, H., Quach, U., Singer, P. A. and Daar, A. S. (2004) The scientific muscle of Brazil's health biotechnology. *Nature Biotechnology*.

Freeman, C. and Soete, L. (1997) *The economics of industrial innovation.* MIT Press: Cambridge, Massachusetts.

Garelli, S. (2003) Competitivness of nations: the fundamentals. *IMD World Competitiveness Yearbook. Competitiveness Project***,** 702-713.

Gastrow, M. (2008) Great expectations: The state of biotechnology research and development in South Africa. *African Journal of Biotechnology,* 7**,** 342-348.

Glick, J. L. (2008) Biotechnology business models work: Evidence from the pharmaceutical marketplace. *Journal of Commercial Biotechnology*.

IDRC (1993) Towards a Science and Technological Policy for a Democratic Sout Africa: Mission Report. Canada, IDRC.

Kong, S. K. (2001) The competitiveness of biotechnology in Japan. *International Journal of Biotechnology,* 3**,** 184-198.

Leedy, P. and Ormrod, J. (2001) *Practical Research: Planning and Design.* Prentice-Hall, Inc.: New Jersey.

Lingela, V. and Buys, A. (2007) *An Innovation managment framework to improve national competitiveness in developing countries.* In: 16th International conference on Management of Technology, May 13-17, 2007, Miami, Florida, USA. International Association for Management of Technology 2007 Proceedings.

Martin, R. and Sunley, P. (2003) Deconstructing cluster: chaotic concept or policy panacea? *Journal of economic geography,* 3**,** 5-35.

Mola, E. L., Acevedo, B. E., Silva, R., Tormo, B., Montero, R. and Herrera, L. (2003) Development of Cuban biotechnology. *Journal of Commercial Biotechnology,* 9**,** 147-152.

Motari, M., Quach, U., Thorsteinsdottir, H., Martin, D. K., Daar, A. S. and Singer, P. A. (2004) South Africa-blazing a trail for African biotechnology. *Nature Biotechnology,* suppl. Dec 2004**,** DC37-41.

Mulder, M. and Henschel, T., (2003) National Biotech Survey 2003. Johannesburg: Egoibio. Available from:http://www.pub.ac.za/resources/docs/egolibio_survey_2003.pdf (accessed 15 February 2008).

Mullen, J. C. (2007) In *Beyond Borders: Global Biotechnolgy Report 2007*(Ed, Jaggi, G.) Ernest & Young, pp. 5-8.

Ndhlovu, R. (2007) *An exploration into the feasibilty of a research and development cluster in the South African Pharmaceutical Industry*. MBA, University of Pretoria.

Nonaka, I. and Takeuchi, H. (1995) *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation.* Oxford University Press, USA: New York.

Porter, M. (1998a) Cluster and the New Economics of Competition. *Harvard Busness Review*.

Porter, M. (1999) Michael Porter on Competition. *ANTITRUST BULLETIN,* 44**,** 841-880.

Porter, M. E. (1990a) *The competititve advantage of nations.* Free Press: New York.

Porter, M. E. (1990b) The competitive advantage of nations. *Harvard Business Review,* March/April**,** 73-93.

Porter, M. E. (1998b) *On competition.* Harvard Business School Press.

Pouris, A. (2007) Department of Science and Technology *National Biotechnology Audit 2007: Biotechnology Use and Development in South Africa (Confidential Report)*. Pretoria.

Prahalad, C. and Hamel, G. (1990) The core competence of the corporation. *Harvard Business Review,* 68**,** 79-91.

Reiss, T. (2001) Sucess factors for biotechnolgy: lessons from Japan, Germany and Great Britain. *International Journal of Biotechnology,* 3**,** 134-156.

Romer, P. M. (1990) Endogenous Technological Change. *Journal of Technological Economy,* 98**,** S71-S10.

Saludadez, J. and Garcia, P. (2001) Seeing Our Quantitative Counterparts: Construction of Qualitative Research in a Roundtable Discussion. *Forum: qualitative social research [on-line journal],* 2.

Senker, J. (2004) In *The Economic Dynamics Of Modern Biotechnology*(Eds, McKelvey, M., Rickne, A. and Laage-Hellman, J.) Edward Elgar Publishing, Cheltenham.

Senker, J., Reiss, T., Mangematin, V. and Enzing, C. The effects of national policy on biotechnology development: the need for a broad policy approach. *International Journal of Biotechnology,* 9**,** 20-38.

Senker, J., Reiss, T., Mangematin, V. and Enzing, C. (2007) The effects of national policy on biotechnology development: the need for a broad policy approach. *International Journal of Biotechnology,* 9**,** 20-38.

Smith, A., Coetzee, K. and Mulder, R. J. (2005) Access Market International *Western Cape MEDS Biotechnology Research Study for Western Cape-Department of Economic Development and Tourism*. Cape Town.

Teece, D., Pisano, G. and Shuen, A. (1997) Dynamic Capabilities and Strategic Management. *Strategic Management Journal,* 18**,** 509-533.

Thorsteinsdottir, H., Quach, U., Daar, A. S. and Singer, P. A. (2004) Conclusions: promoting biotechnology innovation in developing countries. *Nature Biotechnology*.

Tidd, J., Bessant, J. and Pavitt, K. (1997) *Managing innovation.* Wiley New York.

UNDP (2001) UNDP *Human Development Report 2001: Making new technologies work for human development*. New York.

Welman, J. and Kruger, S. (2001) *Research methodology for the business and administrative sciences.* Oxford University Press Oxford.

Wolson, R. (2005) Towards the establishment of a vibrant South African biotechnology industry: will the recent policy interventions achieve their objectives. *International Journal of Biotechnology*, 7**,** 147-160.

Young, E. (2006) *2006 South African Biotech Review: Discussions with industry stakeholders*.

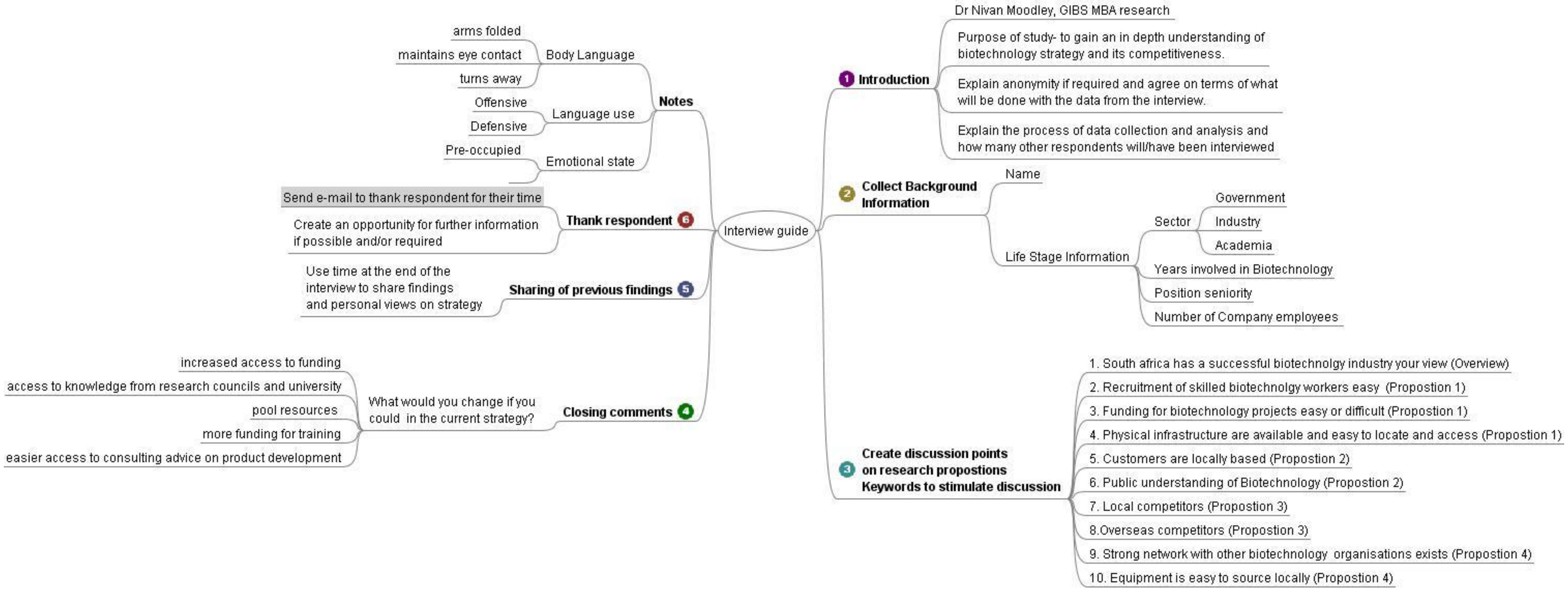
Young, E. (2007) *Beyond Borders: Global Biotechnology Report 2007*.

Zechendorf, B. (2004) Biotechnology policy in European countries: An assessment. *Journal of Commercial Biotechnology,* 10**,** 340-351.

Zhenzhen, L., Jiuchun, Z., Ke, W., Thorsteinsdottir, H., Quach, U., Singer, P. A. and Daar, A. S. (2004) Health biotechnology in China-reawakening of a giant. *Nature Biotechnology*.

Zikmund, W. G. (2003) *Business Research Methods.* Thomson: South-Western: Kentucky.

# Appendix A: Interviews - Researchers Guide



# Appendix B: List of Participant Organisations in Study

| Organisations | Number of Participants |
|---|---|
| Department of Science and Technology | 2 |
| CSIR | 3 |
| Arvir Technologies | 1 |
| Elevation Biotech | 1 |
| University of Pretoria | 3 |
| BioPad | 1 |
| MRC | 1 |
| Bioventures | 1 |
| Bioclones | 1 |
| DTI SEDA | 1 |
| Blue Sky Venture | 1 |
| Sylvean Biotech | 1 |
| Sugar Mill Research Institute | 1 |
| iThemba Pharmaceuticals | 1 |
| Innovation Fund | 1 |