Innovation in the Western Cape: Identifying Mechanisms to Enhance University-Industry Collaboration

A Research Report

presented to

The Graduate School of Business
University of Cape Town

In partial fulfilment
of the requirements for the
Masters of Business Administration Degree

by
Kyle Zietsman

December 2011

Supervised by: Dr. Andrew Bailey
1 Plagiarism Declaration

I know that plagiarism is wrong. Plagiarism is to use another’s work and pretending that it is one’s own.

I have used a recognised convention for citation and referencing. Each significant contribution and quotation from the works of other people has been attributed, cited and referenced.

I certify that this submission is my own work.

I have not allowed and will not allow anyone to copy this document with the intention of passing it off as his or her own work.

Kyle Zietsman
2 Abstract

This study provides an overview of university-industry collaboration within the province of the Western Cape, South Africa, and highlights the barriers to successful collaboration within the biotechnology, pharmaceutical and medical device industries. Interviews were conducted, and surveys completed by various role-players in the province’s business landscape, including companies in the focal sectors who are actively pursuing research and development within the province. The analysis was done using a systems model to describe the mechanisms that create the outcomes observed in the research. The main hurdles for university-industry collaboration identified are communication, conflicts of interest, perceptions around the IPR Act, culture and the control of IP generation. These factors are addressed by suggesting countermeasures to mitigate the root causes of the problem.

Keywords

Technology transfer, innovation, university-industry collaboration, Intellectual Property (IP) management, Triple Helix of innovation, Intellectual Property Rights from Publicly Financed Research Act (IPR Act), Western Cape, research and development (R&D), biotechnology, pharmaceutical, medical device.
# Table of Contents

1. Plagiarism Declaration ........................................................................................................ i 
2. Abstract .............................................................................................................................. ii 
3. Table of Contents ............................................................................................................. iii 
4. List of Figures and Tables ................................................................................................. vi 
5. Acknowledgements .......................................................................................................... vii 
6. List of Abbreviations ..................................................................................................... viii 
7. Introduction .................................................................................................................... 1 
   7.1 Research Area ............................................................................................................. 1 
   7.2 Research Problem ....................................................................................................... 1 
   7.3 Purpose and Significance of the Research ................................................................ 2 
   7.4 Research Questions and Scope .................................................................................. 3 
   7.5 Research Assumptions ............................................................................................... 4 
   7.6 Research Ethics ......................................................................................................... 5 
8. Literature Review ............................................................................................................. 5 
   8.1 Introduction to IP Management .................................................................................. 5 
   8.2 Stakeholders .............................................................................................................. 7 
   8.3 National Policies and Frameworks ............................................................................ 7 
   8.4 Regional Context of University – Industry Collaboration ........................................ 9 
   8.5 Focus on Sectors ...................................................................................................... 10 
   8.6 Means and Methods of Technology Diffusion ......................................................... 10 
   8.7 Hurdles to Successful University-Industry Collaboration ......................................... 14 
      8.7.1 Inflexible University Negotiation ................................................................. 14
8.7.2 IP Valuations...................................................................................................... 14
8.7.3 Conflicts of Interest and Organisational Setup .............................................. 15
8.7.4 Knowledge of Industry Needs ......................................................................... 16
8.7.5 Lack of preparedness by the Licensor/Licensee ............................................... 17
8.7.6 Finding Exploitable Innovations....................................................................... 17
8.7.7 Regulatory Environment.................................................................................. 17
8.7.8 Location.......................................................................................................... 17
8.8 Literature Review Conclusion ........................................................................... 18
9 Research Methodology .......................................................................................... 19
  9.1 Research Approach ............................................................................................. 19
  9.2 Research Design, Data Collection Methods and Research Instruments .......... 20
  9.3 Sampling............................................................................................................. 21
  9.4 Data Analysis Methods ....................................................................................... 22
10 Research Findings and Discussion ....................................................................... 23
  10.1 A Perspective of the Western Cape ................................................................. 23
  10.2 Context of how Companies Source Technology ............................................. 26
  10.3 Networks........................................................................................................... 30
  10.3.1 Innovation as a People Driven Concept....................................................... 31
  10.4 Government Systems in Place to Assist ......................................................... 33
  10.5 Conflict of Interest............................................................................................ 35
  10.6 Interaction of Students with Companies............................................................ 36
  10.7 Culture............................................................................................................. 38
  10.8 IP Ownership.................................................................................................... 40
11 Research Analysis and Recommendations .......................................................... 41
  11.1 Interrelationship Diagraph............................................................................... 41
  11.2 System Model................................................................................................... 43
4 List of Figures and Tables

Figure 1 Provincial research collaboration at UCT (2010) (Data source: RCIPS) .................24
Figure 2 Western Cape statistics as a proportion of South African figures – Data source (OECD, 2008) .................................................................................................................. 25
Figure 3 Technology class of Western Cape manufacturing firms – Data source (OECD, 2008, p.106) ...............................................................................................................26
Figure 4 Manners in which companies source their technology in focus sectors ..............30
Figure 5 Industry's previous interactions with university ..................................................32
Figure 6 Interrelationship diagraph ..................................................................................42
Figure 7 System model of University-Industry Collaboration ...........................................44
Figure 8 Mechanism 1- Primary Causal loop (Part of overall system diagram-Figure 7) ....45
Figure 9 Mechanism 2- Secondary Causal loops (Part of overall system diagram-Figure 7) 47
Table 1 Analysis summary of interventions and mechanisms ............................................49
5 Acknowledgements

I would like to thank the following people whose help is acknowledged in the generation of this research report.

- Andrew Bailey, for your guidance throughout the research process and for providing valuable information, contacts and clarifications in the technology transfer space. Your lightning-speed feedback was most certainly very much appreciated.
- To all the participants in this research. The interviews and survey feedback provided many valuable insights that extended further than the scope of this research report.
- To all my friends who I have turned down weekends away with – thanks for your patience, I am ready to head out on some more adventures.
- To my family who have provided support thought this process, and the MBA year.
- To the full time MBA class of 2011 – what a superb year with you all, there are some friendships made to cherish.

And finally, I would like to thank my wife Simône – your patience and support thought this year has been second to none! You have given me the strength to tackle the challenges and most importantly to provide a pillar of optimism and support for the times ahead.
6 List of Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DTI</td>
<td>Department of Trade and Industry (South Africa)</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross domestic product</td>
</tr>
<tr>
<td>IDC</td>
<td>Industrial Development Corporation</td>
</tr>
<tr>
<td>IP</td>
<td>Intellectual property</td>
</tr>
<tr>
<td>IPR Act</td>
<td>Intellectual Property Rights from Publicly Financed Research and Development Act 51 of 2008 (South Africa)</td>
</tr>
<tr>
<td>IT</td>
<td>Information technology</td>
</tr>
<tr>
<td>MIT</td>
<td>Massachusetts Institute of Technology</td>
</tr>
<tr>
<td>O</td>
<td>Opposite direction (systems model)</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research and development</td>
</tr>
<tr>
<td>S</td>
<td>Same direction (systems model)</td>
</tr>
<tr>
<td>SA</td>
<td>South Africa</td>
</tr>
<tr>
<td>SARS</td>
<td>South African Revenue Services</td>
</tr>
<tr>
<td>SPII</td>
<td>Support Programme for Industrial Innovation</td>
</tr>
<tr>
<td>THRIP</td>
<td>Technology and Human Resources Program</td>
</tr>
<tr>
<td>TIA</td>
<td>Technology innovation agency</td>
</tr>
<tr>
<td>TTO</td>
<td>Technology transfer office</td>
</tr>
<tr>
<td>UCT</td>
<td>University of Cape Town</td>
</tr>
<tr>
<td>US</td>
<td>University of Stellenbosch</td>
</tr>
<tr>
<td>USA</td>
<td>United States of America</td>
</tr>
<tr>
<td>WC</td>
<td>Western Cape</td>
</tr>
</tbody>
</table>
7 Introduction

7.1 Research Area
The recent implementation of the Intellectual Property Rights (IPR) from Publicly Financed Research and Development Act in South Africa (SA) has meant that “intellectual property emanating from publicly financed research and development is identified, protected, utilised and commercialised for the benefit of the people of the Republic, whether it be for a social, economic, military or any other benefit.” (NIPMO, 2008, p.4).

The basic premise of this Act is to enable the commercialisation of research at universities to ensure that taxpayers benefit from research that is funded through public funds, and provide a means by which research can drive economic growth. A key facet of the implementation of this Act, is the requirement for universities to set up technology transfer offices (TTO), whose aim it is to identify and assist researchers capitalising on the innovations that stem from the research (Bailey, 2010). The underlying concept that the act aims to foster is one of effective technology transfer.

Technology transfer is the transfer of technology and knowledge between the stakeholders involved in the innovation value chain. Technology transfer is also discussed as technology diffusion, which requires an innovation transferor and innovation adopter. Technology transfer is closely linked with innovation management, which is the manner in which a company or institution manages its portfolio of intellectual property or knowledge. This encompasses research and development, patenting, licensing and transfer of technology.

7.2 Research Problem
Innovation management and the link between university-industry collaboration is a widely studied theme which has importance to all stakeholders; government, academia, and industry. Much of this research has been done following the implementation of the Bayh-Dole Act in the United States of America (USA) with its aim of stimulating the efficiency of technology transfer from university and implementing the technology as a commercially viable asset in industry. The context within which this research relates to is that of developed countries, and
little documented research has been applied to the emerging economy or developing market context (Blankley, Scerri, Malotja, & Saloojee, 2006).

Despite the abundance of research, evidence of frustration felt amongst the relevant stakeholders with regard to the hurdles posed abounds - overcoming the hurdles between industry - university collaboration and technology transfer remains a problem. An example of a region facing this challenge is the Western Cape in South Africa. In light of this, the Department of Science and Technology in South Africa commissioned a report to establish the innovation networks between the stakeholders (CeSTII, HSRC, & DST, 2009). This report aims to identify strengths that are evident in the communication networks between the stakeholders, so that these can be leveraged to unlock further growth within the province of the Western Cape.

Following this report, there have been other studies and situation analyses undertaken by Nicol (2010) and COFISA (2009) aimed at identifying hurdles for the technology transfer process, and to propose solutions that may aid the system in gaining momentum. However frustration levels were still evident at a conference amongst the stakeholders aimed at finding solutions to effective collaboration and technology transfer (Conference title: Stimulating university-industry and university-community engagement in Cape Town, held on 17 August 2011). In light of this situation, this research aims to explore the causal mechanisms which are evident in creating these barriers to successful technology transfer. In identifying these, the research aims to unlock the pathway to potentially find facilitating solutions to the matter at hand, while at the same time identifying key sector technology acquisition characteristics that are evident in the region.

7.3 Purpose and Significance of the Research
The purpose of the research is to undertake an explanatory study which will attempt to find the causal mechanisms which give rise to the issue of technology transfer barriers. In doing so the researcher aims to understand the process of university-industry collaboration in more detail, so as to provide a basis from which appropriate actions or policy can be implemented. Further to this the research, the need occurs to identify requirements from the stakeholders in the communication of technology and industry needs. A potential spin-off of the research is
that it has the potential to identify university-industry collaboration opportunities that may exist in the region, or ones that may become evident in the region’s developing industries.

The significance of this is that it aims to build upon the theory that exists in the space of technology transfer and innovation management. The particular focus will aim to enable the collaboration networks between university and industry, so that a practical solution to the problem can be tabled. In doing so, there stands to be significant benefit in the Western Cape in terms of value generated for the regional economy and job creation, thus aiding the vision of the IPR Act - to commercialise research for the benefit of South Africans. The research also aims to develop further theory on the stakeholder network efficiency and effectiveness which is stated as potential area for further research in the source (COFISA, 2009).

7.4 Research Questions and Scope

The context within which the research question is posed is specifically aimed at the regional context of the Western Cape, South Africa. Further to this, the Triple Helix stakeholders (academia, government and industry (Leydesdorff & Etzkowitz, 1998)) in the industry form the greater scope within which the region is analysed.

The main research question posed in this research is:

**What are the underlying mechanisms which pose hurdles for the successful transfer of technology and innovation?**

In researching this question, the following sub questions are answered:

- What is the current level of university-industry interaction in terms of technology acquisition?
- What are the key avenues through which companies in key sectors source their technology, and how important is the acquisition of new technology perceived to be for their core business? In this case, technology acquisition also refers to the development of a company’s own technology.
- How aligned are universities to meeting the technology needs of industry in the selected sectors?
• What needs to be done to improve communication of needs and products between stakeholders?
• What are the enablers and barriers to technology diffusion and communication of these needs between parties?
• What is government actively doing with regards to assisting the current situation?
• Are there breakthrough technologies that could influence industries in developing sectors in the region?
• What will be the sorts of collaboration gaps that might need to be filled in future?
• By enhancing enablers, or overcoming barriers to technology diffusion, how will this improve the status quo?

In order to gain depth and work towards answering these questions within the time limitations, the scope of this research covers the pharmaceutical, biomedical and biotechnology industries. The information technology industry was also approached for the research; however certain limitations meant that the depth of analysis for this sector yielded results that were not applicable to the full scope of this research report.

7.5 Research Assumptions

The research assumptions that form the underlying basis of the projects are as follows:

1. The views and experiences that the respondents of the interviews and questionnaires give, are representative of those of their companies and the sector at large. While the researcher attempts to gain as many respondents from the particular industries as possible, the researcher also understands that this may not be practically possible due to the size of the R&D function at the companies interviewed. This assumption is also based on the fact that not all of the personnel approached for response made themselves available for comment.

2. The coding of the interviews mean that there is the chance of the epistemological perspectives of the researcher to influence the propositions to which they refer. In acknowledging this, it is assumed that this influence is minimised by the researcher remaining as objective as possible in data handling.
3. Technology transfer and how a company defines innovation are not bound by standard measures. The measurement of these variables is therefore aligned into specific categories by the researcher. It is assumed that the results generated are consistent with perceptions of the interviewees, and reflect what is done by their company. Where there are additional assumptions made with regards to these categorisations, they are mentioned in the discussion and analysis.

7.6 Research Ethics

In line with the requirements of the research course, fieldwork only commenced once an ethics clearance certificate was granted by the university.

In approaching interviewees and respondents to questionnaires, a brief overview of the research area was given. This aimed to inform the respondents of the usage of the information gained from them. All respondents received the same generic overview and a copy of the interview questions beforehand.

In order to maintain the integrity of the interviewees (including those that participate in the questionnaires) and the companies which they represent, all data is presented without names of persons and companies, or links to these. Interviewees were notified that the single reference to them would be found in the meeting log attached in the appendix. The industry sector from which the information is derived was linked to the given dataset to aid analysis of potential differences between the industries.

8 Literature Review

8.1 Introduction to IP Management

The basic premise of promoting the effective transfer of IP between the universities and the industry is to drive economic growth. Phan & Siegel (2006) state that technology transfer is considered a key driver of economic growth, both regionally and nationally in the United States of America (USA) and the United Kingdom (UK). The primary mechanism by which this occurs is the creation of spin off companies, and via the licencing of technologies to
companies. The benefits of these linkages with universities to the companies that participate in them is as follows: These firms usually have a higher level of innovation; and they tend to register patents more frequently (Arza & Lopez, 2011), all of which makes them better able to be competitive in their business environments.

The history of university technology transfer starting in the early 1900’s is described by Bremer (1998), where for the first time there was a movement away from the “ivory tower” concept and initially little transfer of research to the public domain took place. This type of research relied on the researcher’s ability to see relevance and application of the work in everyday life, and if such a connection could be made, a patentable innovation may have arisen. Bremer (1998) states that there was generally little value in the intellectual property that was generated at that time, until about 1924 when the first university instituted a commitment to seek commercial funding for research to enable intellectual property to generate more relevant research that could translate into value in monetary terms.

Research transferability is key to the success of university-industry technology transfer as stated by Myers (2005). Myers further summarises best practices for this in the context of industry as the following:

- Assign resources wisely – responsible people need to be appointed for technology transfer, and these people need to be held accountable for this
- Ensure effective measurements of successes are in place for technology transfer (royalty income, customer satisfaction, patent applications, citations, etc.)

And from a university perspective:

- Promote excitement about technology commercialisation
- Provide incentives for technology transfer
- Develop competencies of staff for technology transfer
- Develop relationships with industry, and assure that researchers have credibility in this field
- Identify industry technology needs – understanding needs, participate in company needs planning sessions, selecting transferable research
8.2 Stakeholders

The stakeholders involved in the technology transfer arena are governments, academia and industry. These stakeholders are described as the Triple Helix, with the interaction of knowledge flows between these spheres (Leydesdorff & Etzkowitz, 1998). The Triple Helix describes the information flow between the stakeholders, and it is an advancement of the single dimension flow that used to categorise communication between them. The roles of these three stakeholders are interconnected, with universities forming the growth pole or regional innovation organiser (Leydesdorff & Etzkowitz, 1998).

The roles of the Triple Helix network stakeholders can be stated as being “wealth generation (industry involvement), novelty production (academia), and public control (government)” (Leydesdorff & Meyer, 2006, p. 1441). Industry is therefore tasked with creating the economic benefit and value of an innovation, the innovation generation is tasked on the academia, and the government enables the creation and diffusion of these innovations by establishing stimulatory policies and funding. The roles of the network players are sometimes more complex than this, with some of the roles overlapping, and even the internalisation of the roles, such as private company R&D (Leydesdorff & Etzkowitz, 1998). The complexity of the interactions between the parties is what creates the challenge in driving the commercialisation of innovations, and hence an understanding of their role in the region of research is essential.

8.3 National Policies and Frameworks

The Bayh-Dole Act was promulgated in the United States (US), and incorporated in 1980, in order to enable the technology transfer between universities and research industries. The
basis of the Act is to allow universities to retain intellectual property rights from government funded research (Kim, 2010). Kim (2010) states further that this Act has stimulated technology growth due to the fact that innovations discovered from government funded research are more easily accessible to private industry. The implementation of this Act was, in part, responsible for reducing the difficulties faced by incorporating government funded innovations into society.

The spirit of the Bayh-Doyle Act has been emulated across various countries because of the growth effect it has had on the American economy, as stated by Kim (2010). Examples of these countries are Brazil, Australia, Japan, Korea, Switzerland, India, Taiwan, United Kingdom, Germany, France, and Turkey, in addition to South Africa.

A key feature of the Bayh-Dole Act is that university technology transfer offices (TTO) were set up to protect and manage the diffusion of IP. There are various existing theories which characterises the success of these TTO’s in commercialising university IP. These are based on the factors of financial promise of the success, the structure of the royalties to the innovation team, and entrepreneurship capabilities at these institutions (Phan & Siegel, 2006). The basis of this study is to synthesise theory from a business perspective, so these items are not discussed in detail in this literature review. It is however noted that the policy frameworks in South Africa are an important factor to the context of university-industry collaboration in the province.

Post the inception of the Bayh-Dole Act, many universities began to take a more aggressive stance towards commercialising IP, and as such their licencing agreements became more and more stringent (Myers, 2005). This meant that companies found it difficult to take full ownership of the IP. One exception to this was the biotechnology and drug companies which tended to outsource much of their research to universities, and ensured that the research that they sponsored became their property. This is one of the pivotal factors that Myers (2005) cites as contributing significant IP revenues to universities. The fact that the pharmaceutical industry generally has a good history with university-industry collaboration is a key reason why it is incorporated as a focus sector in this research.

While the scope of government policy plays a strong role directly linked to the formation of technology in a country, they have a much larger and important role to play – this role is the investment in education (WIPO, 2011). One cannot discount the importance of feeding
graduate people into the workforce to aid the region’s economic development. The relevance of this to the research question posed is to appreciate the roles that business envisions universities playing in their innovation process.

8.4 Regional Context of University – Industry Collaboration

Waugaman et al. (1999) discusses the ability of universities in a region to transfer technology. The regional universities described in the study had performance levels that were sub-standard when compared to other regions, or even on a national comparative. Although it is complex to define the exact reasoning behind this, Waugaman et al. (1999) looked at the matter of an external patent council and how this influences technology transfer in the region. Their findings were that universities should share useful business practice ideas with regards to technology transfer, build up a collaborative record or “guidebook” to record this information, and develop more effective means of collaboration. These collaborative forms of interaction in the article, all recommend that an external patent council is engaged in the process. This makes the process more formal and “business like”, but it does also increase the cost of managing this technology transfer which in itself is a hindrance to successful technology transfer.

Further reinforcing the ideas of collaboration is Breschi & Catalini (2010) who explore the overlap of connectedness in the communities within which the innovation transfer is going to take place. Although their study is in line with logical understanding of the way networking works, they do state that the project champions need to have a high degree of connectedness in the industry to ensure that the transfer will be a success.

The importance of innovation transfer to regional competitive advantage is studied by Quatraro (2009), who states that “the emergence of innovation capabilities within a regional context is strictly related to relative stage of development of the propulsive industry and of its related industries” (p.1346). This relates to growth pole theory which states that the development of a regional pole takes place around the presence of an industry, and further development of sub industries take place around this due to either direct or indirect effects (Rodrigue, 2011). The importance of this is that as these growth poles mature and their growth slows, so does their rate of innovation (Quatraro, 2009). Although this study was in the context of Italian cities, this is seen as a relevant factor in the Western Cape, and the
economic growth factors of the region need to be considered when making judgement of the innovation transfer capability of the region.

A key statement that emerged from (Quatraro, 2009), is; “the increasing availability of public knowledge represents a competitive advantage, provided the existence of conditions enabling knowledge communication and absorption” (p.1346). In the Italian context, it was found that where there were large technology based districts surrounding poles of greater research and development spending it translated into noticed economic competitive advantage. Although this study refers to the availability of public knowledge driving the economy, the crucial factor that is not explicitly linked to the study, is the availability of funding for this research to be diffused within the industry.

8.5 Focus on Sectors

One of the reasons that drove the focus on the biomedical and pharmaceutical industries in this research is the fact that in the United States of America, most of the royalties paid by companies to universities for IP are related to these sectors (Myers, 2005). Although the context of this research focuses on the Western Cape, the fact that these industries pose such a great opportunity for successful technology transfer implies that there is a need to research this field further and establish the reasons behind this success relative to industries that do not have this experience. With regards to results that are generated in this regard, caution is taken to adequately compare the relevant and hence correct data against the region in context.

In the context of Canada, government was concerned with the efficacy of the healthcare innovation system, and as such has invested in establishing means to improve the innovation transfer mechanisms (Alice, Sanders, & Lehoux, 2009). Both the identification of these hurdle factors to successful research and the subsequent emergence of a promising commercial product are imperative to maximising the value of public sector investments. Although the contexts differ, this same reasoning can be applied to the South African context.

8.6 Means and Methods of Technology Diffusion

Twenty three different types of university-industry collaboration are identified in the sources; Bekkers, Maria, & Freitas (2008); Waugaman, Vickery, & Tornatzky (1999); and Manrique
et al. (1985) - these are listed in Appendix 15.5. The importance of acknowledging these forms of diffusion in the literature review is that the research aims to identify how technology is sourced by industry in the region, and therefore an understanding of the various manners by which this is performed is required.

There are generally two means of diffusion in the innovation process – these are technology driven “push” factors, and demand driven “pull” factors (Atun, Gurol-Urganci, & Sheridan, 2007). The types of technology that “push” models to develop may have fewer applications than that of the “pull” applications. It is also stated by Atun et al. (2007) that medical, pharmaceutical and biomedical applications generally work of the “pull” model, and therefore there are many innovations which do become commercially viable. This is a key facet in the innovation space, as these industries have generally been found most successful in the university –industry collaboration. The evidence backs this up, with these industries also contributing to a large portion of the university funding (Phan & Siegel, 2006). The importance of the type of innovation that is studied, how this is dispersed within the market, and the market conditions may all yield influence on the degree of success of university-industry collaboration.

In the instance of the medical sector, where the use of university driven research carries significant importance, an increase in the amount of published research increases the rate of technology diffusion, and in turn drives the rate at which ideas are generated and spread (Genuis, 2005). This is due to the fact that it does provide a mechanism, by which complimentary innovations may be generated, but most importantly it also provides a respected communication medium amongst the industry players - this is also relevant to the medical device sector.

The degree to which technology could be deemed applicable in a market and its relevance in industry highlights the importance of the technology to be diffused to be widely diffused in the first place. Arakji & Lang (2010) describe factors that are relevant to the rate of vertical technology diffusion. These are: The selective advantage of the innovation; and the relative growth rate of the innovation (this relates to its appeal and environmental factors in the industry). Further to this, Arakji & Lang (2010) state that the long term fate of this innovation in the industry is dependent on the rate of vertical and horizontal diffusion. The diffusion types can be explained by Manrique, Marcén, Maza, Olaizola, & Servet (1985) who
describe vertical diffusion as those which can be applied to solve problems in a particular business, and horizontal diffusion as those which can be applied to solve market wide problems.

The role of innovation hubs is important in the arena of technology diffusion, and in particular to the region of the Western Cape where they have been implemented to promote the generation of IT innovations (COFISA, 2009). The role of innovator hubs have a notable impact on the rate of innovation adoption, and follower hubs assist with aiding a faster penetration of the innovations to the market (Goldenberg, Han, Lehmann, & Hong, 2009). Although there can be some overlap in the two types of hubs, the benefits of these hubs is the key premise for regional statutes developing them.

An example of a type of hub that has developed as a means to start spin off companies resulting from research is that of an incubator. The role of incubators is described by Etzkowitz (2002) as having “developed technology and business ideas into an array of firms and to form research centres by fusing heterogeneous R&D entities from university, government and industry.” (p.115). One of the key benefits of incubators is their ability to internalise the roles of the Triple Helix network players, which aid in overcoming the hurdles created in university-industry collaborations. This element highlights the reasoning behind judging the relevance of these hubs to the focal sector businesses.

The importance of the incubator model is described as “university’s three missions of teaching, research and economic development which are evolving along parallel paths from an individual to a group perspective and from being merely a facilitator for transferring technology to individual firms to being a force for fostering regional economic and social development.” (Etzkowitz, 2002, p.121). This again highlights the need for fostering successful technology transfer within a regional context to enhance the economic standing of the region.

The roles of spin-off companies to the field are extremely important. Not only do they stimulate value creation and increase employment, but they also are said to be a very effective form of technology transfer (Rogers, Takegami, & Yin, 2001). This deduction does follow logical process, but developing the correct form of technology to form the spin-off company involves a deep understanding of what exact technology is required in the industry in question.
Another effective means of technology transfer is that of open-market innovation. Open-market innovation is described as “an approach that uses tools such as licencing, joint ventures, and strategic alliances to bring the benefits of free trade to the flow of new ideas.” (Rigby & Zook, 2002, p.82). The core of open-market innovation is to open the company doors to innovation from within - which will also allow the company to explore which other companies may be interested in creating a joint alliance. This form of partnerships allows companies to set realistic values for their innovative ideas, and the increased communication with interested parties, including outsourcing, allows innovations to be developed quicker and be brought to the market sooner (Rigby & Zook, 2002).

There may also be strategic advantage to adopting this form of disclosing intellectual property - Comerford (2007) discusses such applications as disclosing IP to prevent competition from patenting it. This is due to the novelty of the concept then becoming public knowledge, and as such would not be patentable. An interesting form of strategic risk management that IBM uses in the protection of their IP is discussed by Myers (2005). In this instance, IBM generally licenses ideas where the company may in the future infringe on the patents, or where there is a high likelihood that their current products infringe on the patent.

The basic premise of releasing innovations carries inherent risk, but if managed properly, the benefits can far outweigh the risk. A few reasons drive this notion: Technology transfer takes time – once the deal is signed, the purchaser needs to customise the innovation to their requirement and the market it operates in and get it diffused into the hands of the purchasers and users (Rigby & Zook, 2002). These processes rarely take less than a year, and generally take up to 36 months. Rigby & Zook (2002) also state that the fact that purchasers of an innovation are rarely able to capitalise and replicate the full value of the innovation (to the extent that the originator has) and that this further increases the risk inherent to technology transfer.

There may be market considerations that justify the release of intellectual property for free. These may include the aim to increase an individual’s name in the industry, or to increase the market for one’s innovation (Hippel, 2002). Of course many strategic cases for this can be applied - Myers (2005) discusses the case of IBM, which uses the open-market innovation in their operations, and states that one of the biggest challenges that they face in disclosing IP is the fact that their customers are also their competitors. This means that risk management and
the knowledge of the value of that IP to the internal researchers projects is important when using an open-market innovation approach. While this form of technology transfer has its benefits, it is generally only used in the information technology space, but its applicability to other forms of business is becoming more and more prevalent (WIPO, 2011).

8.7 Hurdles to Successful University-Industry Collaboration

An analysis of some of the hurdles imposed on business-university collaboration, which are highlighted in the literature, are discussed below. These factors have been highlighted as sole acting factors in the various contexts of the reviewed research, and are all evident in the COFISA (2009) report on innovation networks in the Western Cape. All these factors have evident interlinking causes, which this research aims to clarify within the scope and context that it is presented.

8.7.1 Inflexible University Negotiation

Powerful technology transfer partners have many options with regard to technology transfer (Myers, 2005). Therefore, if universities take an inflexible stance on the relationships with these partners, even if this inflexibility is merely perceived - they may look elsewhere. This inflexibility has in some cases been attributed to the lack of experience of the university negotiators to the industry that the partner may be involved in (Myers, 2005). The context of this source is the United States where there is generally a high amount of available funding for technology transfer, hence a larger amount of bargaining power on the universities.

8.7.2 IP Valuations

A lack of knowledge pertaining to the true value of an invention can lead to a commercial inventor being pressurised into closing a deal or look for a more quick payoff for the invention (Myers, 2005). This is one of the factors where the Bayh-Dole Act assisted universities, in that they had the choice of when to let deals go ahead or not, given the fact that they owned the underlying technology. Harnessing this is the notion that IP should be an asset to a company, and managers need to know how IP is working for them (Jolly & Philpott, 2004). The role of the university TTO plays an integral part in establishing the
commercial expectations of the role-players in technology transfer (Mars & Hoskinson, 2010). Some of the responsibilities that Mars & Hoskinson (2010) state include managing the agendas of the role players, clarifying the nature of the endeavour and clarifying the ownership rights of the various parties.

8.7.3 Conflicts of Interest and Organisational Setup

The conflict of the requirement to publish research versus the filing for patents may lead to important discoveries being downplayed so that research does not have to wait for the patent process before being published (Myers, 2005). This closely links with the nature of the team structure that relates to technology commercialisation projects, and how each is incentivised to deliver the commercialised product (Kingon, Baker, & Debo, 2010). The skills required to carry out technology transfer process is something that South Africa has on its agenda to foster (Bailey, 2010).

Building on this, Vincent (2010) concludes that the social and task oriented processes of teams in technology commercialisation projects are always more effective when the dynamics and team structure are established early on in the project phase. Although this seems like a straightforward observation, this may be an important factor which contributes to the trust felt in the teams under consideration.

Rogers et al. (2001), identifies a key driver in the creation of spin-off companies, as enabling policies of R&D organisations. These policies include incentive schemes, entrepreneurial leave and are closely linked to ensure that they lower the risk of conflicts of interest in the R&D workspace.

A study of the organisational hurdles that hamper university-technology transfer are outlined by Siegel, Waldman, Atwater, & Link (2004). Their findings suggest that cultural and informational barriers in communication between the stakeholders in the Triple Helix are one of the serious hurdles that need to be addressed. Further to this they mention other factors such as remuneration and incentives of people involved in technology transfer, which also facilitate the process of successful technology transfer.

The capacity of universities and industry to cooperate is one of the factors that are expected to be a focal point of this research. This is highlighted and explored in research by Fini &
Lacetera (2010), who argue that the different mandates of educational and commercial institutions means that requirements for the outcomes of research are fundamentally misaligned.

### 8.7.4 Knowledge of Industry Needs

The lack of this knowledge is one of the largest hurdles experienced in university-industry IP commercialisation (Myers, 2005). Comerford (2007) reinforces this, by finding that communication between both parties is a prerequisite for successful technology transfer. Jolly & Philpott (2004) also identify communication as a crucial element in transferring technology between organisations.

The pivotal role and necessity of a researcher’s connectedness to industry is reinforced by Breschi & Catalini (2010) as being critical for successful technology transfer. They infer that the connectedness of the researcher to the industry means that not only do they understand what research will add value to the industry, but to also use these networks to diffuse the innovation within the industry, which is imperative to its commercial success. Gibson & Smilor (1991) reiterate the theory that communication interactivity is a key variable in technology transfer. A case where this mechanism of understanding the needs of a particular industry is highlighted, is in the field of nanotechnology as described by Nikulainen & Palmberg (2010). This case states that not only the industry network of the researcher is a critical factor in successful technology transfer, but also the identification and in-depth knowledge of industry needs. This highlights the challenge faced in studying the interactions between the Triple Helix players, and this needs to be taken into account when drawing up conclusions to this research.

Small entrepreneurial firms are a key ingredient to create successful technology transfer from a university (Kassicieh, Kirchhoff, Walsh, & Mcwhorter, 2002). While this idea is linked to incubators and spin-off companies from technology transfer offices, the agility of these firms are directly liked to their networks and their interconnectedness to industries in the region within which they operate.
8.7.5 Lack of preparedness by the Licensor/Licensee
Comerford (2007) states that a lack of preparedness may be due to the fact that technology transfer has not been carried out before, or that there has been a lack of information carry over in that specific role in the company. A possible reason for this may lie in the step wise change in technology that has presented itself, and that there may not be adequate knowledge on the subject to be able to deal with it (Comerford, 2007). This type of problem is exacerbated by high employee turnover.

8.7.6 Finding Exploitable Technology
Only a very limited number of inventions have a sensible use, irrespective of how well it is marketed (Jolly & Philpott, 2004). Innovators need to ensure that the technology innovations make something that has tangible benefits relative to other products in their competitive market.

While finding exploitable technology is a direct link to communication and connectedness with industry partners, the “push” side of getting innovations to the market is creating an entrepreneurial type facilitation policy to aid spin-offs (Toole & Czarnitzki, 2007). This type of policy primarily aims to educate researchers of methods how to get their research to the market.

8.7.7 Regulatory Environment
The regulatory environment within which the innovation is to enter the market poses a potential barrier to its diffusion (Atun et al., 2007). Licencing, price controls and taxes are all methods of regulation affecting the rate of technology diffusion.

8.7.8 Location
The regional location of a company is described as being a key variable for successful university-industry collaboration (Gibson & Smilor, 1991). Their studies show that long term research assignments may generally go ahead without issue if the industry partner is distant, but short term research projects need the industry partner to be in close proximity. The
relevance of this factor to this study is that types of collaborators and their geographical location could become an important factor in studying the hurdles to technology transfer.

8.8 Literature Review Conclusion

The literature review provides an overview of university-industry collaboration and highlights the importance for it to be stimulated and fostered within a regional context. The main hurdles for university-industry collaboration highlighted are; inflexible university negotiation, IP valuations, conflicts of interest between parties involved, knowledge of industry needs, lack of preparedness by the parties involved, ability for the various innovations to be exploitable, the regulatory environment present, and the location of the technology acquirer in relation to the academic institution. These hurdles given across the range of references all pertain to the context of the United States or other developed nations, where there is significant financial stimulus set aside for technology transfer.

Although these hurdle factors are acknowledged by the stakeholders in the Western Cape, means and processes to address them need to be applied to the root causes of the problem. It is in this area where this research report aims to build on the theory presented in the literature review. In approaching this, the literature highlights the imperative need to investigate the manner in which a company sources technology - to identify the perceived importance of universities to companies in the province.

The hurdles isolated in the literature may not pertain to the context of the Western Cape. This is due to the different economic factors present in a developing nation, as well as the unique nature of industry in the Western Cape. This explains the need to further elaboration on the hurdles isolated in the literature and their relevance, if any, to the business in the province. In researching this it needs to be established how companies have interacted with universities in the past, and their plans on interacting with universities in the future. By analysing this, one could unlock root causes to the issues.
9 Research Methodology

The basis for the research approach follows the guidelines of Rigby & Zook (2002) who outline a recommended methodology for innovation assessment. This study is an empirical qualitative review which is carried out with the strategy and data collection methods as described later in this section.

The study is of the explanatory type (Blanche, Durrheim, & Painter, 2006), using inductive methods to describe the scenarios that are described by the respondents. The analysis of the research questions is done via a critical realist perspective where ontological perspectives of the views of the stakeholders are analysed. This type of methodology is similar to that used in different contexts to reveal similar findings by Gibson & Smilor (1991).

9.1 Research Approach

The approach in addressing this research questions is to conduct an empirical qualitative analysis of the questions involved. The basis of this is composed of a mixed form of data collection - that of both questionnaires and interviews, with key individuals involved in R&D aspects of the companies that are under consideration, and other players in the Triple Helix network in the province. The questionnaire component is incorporated so that there can be a larger pool of respondents engaged in this study who would be unable to participate in an interview with the researcher.

The questionnaire component is designed so that questions are answered on a Likert-scale basis, as well as some responses to the questions posed in writing. This approach allows for trends to be included, whilst still allowing for qualitative data to be coded. The latter forms will be a small portion of the questionnaire, and aims to quantify the percentage of respondents experiencing the listed barriers to collaboration. Due to the small size of the samples, and the populations, it is noted that the percentages of occurrence of a variable may not be accurate, but it does give an indication of the trends that are present in the industry (Bryman & Bell, 2007).

The interview component of the research is composed of semi-structured interviews with key personnel involved in the stakeholder organisations. The structure of a partial interview based research allows for more in depth questioning of the mechanisms which influence the
outcomes of the research questions. Consideration is taken to not affect the objectivity of the results, particularly with regard to probing in the interviews. Whilst it is acknowledged that this is not completely possible with a qualitative study, various measures as described by Blanche et al. (2006) are applied, which include, the avoidance of excessive probing, using open ended questions, asking why, and waiting for the interviewee to break silences.

9.2 Research Design, Data Collection Methods and Research Instruments

The approach to the research handling was done in the following manner.

1) Firstly an analysis of the business in the Western Cape was done. This allows for an elaboration of the context of the problem area for the research.

2) Data was sought from the major universities/tertiary academic institutions in the province with regards to their perceptions around university/industry collaboration.

3) Questionnaires were sent to all identified businesses within the scope industries in the region. These questionnaires were sent to companies who have already engaged, are engaging or who have not engaged with university collaboration of any sort. This process was conducted by setting up an on-line questionnaire, a copy of which (including the results) is available in Appendix 15.2. The design of the questionnaire is set out to have questions that are open ended (Bryman & Bell, 2007), which means that the respondents can explore the subject deeper according to their own experience. The questions are based on the concepts that are evident in the research of Gibson & Smilor (1991) and include the effectiveness of different methods of technology transfer, factors facilitating technology transfer, the barriers to technology transfer, and ways to improve technology transfer.

4) Interviews were conducted with key personnel in the proposed sectors of the selected industries in a semi-structured interview format. These sectors were the pharmaceutical, biomedical and biotechnology industries. These interviews were conducted, either telephonically or face to face depending on the location of the company premises and the availability of the interviewee.

5) Additional data is used from Nicol (2010) where the relevant interviews were included in the coding process enabling a richer pool of data.
The interviews were conducted according to the recommendations set out by Bryman & Bell (2007) whilst caution was taken against probing and prompting – these recommendations include:

a) Sending out interview schedule (agenda) and interview questions beforehand.
b) Making the interviewee aware of what the research aim is.
c) Providing a reassurance of confidentiality of the responses to be given to the questions, and reassuring that they will not be linked to any of the data.
d) Identifying the researcher and providing contact details.
e) Identifying how the interviewee was selected.
f) Generating interview notes.

In order to increase the response rate of interview requests and those of questionnaire responses, the researcher took the following action as proposed by Bryman & Bell (2007):

- Telephonically request interviews and responses to questionnaires, followed by an e-mail clarification.
- Telephonically follow up and confirm meeting.
- Clarify the reasons for the research.
- Including clear instructions on how interviews are to be conducted, and how questionnaires are to be completed.
- Including an estimate of the time required.
- Keeping questions succinct.

For the questionnaire, an online survey was done (details attached in Appendix 15.2). The aim of this is to increase the ease of response for the respondents, and also increase the confidentiality of the survey due to the fact that no identifiable e-mails can link respondents to the data.

9.3 Sampling
Research was done to identify all possible businesses in the Western Cape in the focus sectors. Each company identified was asked to do an interview. Where this was not possible, a survey was sent. This was done so that there was no selective sampling process in identifying which businesses were to participate. It is however acknowledged that there is a
possibility for some businesses in the focus sectors not being identified in the research as a result of them being emerging, or not having an established internet presence as yet.

The sampling method used is that of purposive convenience sampling (Blanche et al., 2006). This approach implies that respondents are selected due to them forming part of the focus sectors of the research.

The companies involved in the research questionnaire were selected by the following determining factors:

- Respondents are to be involved in R&D in the Western Cape.
- Respondents are to be in the sectors as focussed on in the research.

The questionnaire questions were also completed by the respondents of the interview sections so that a more complete picture of the sector in the Western Cape could be given. Since questionnaires were confidential, there was no means to identify which companies approached completed the questionnaire or not, so limited scope for follow up was available. There were a total of six respondents to the questionnaire portion of the research, which makes up a response rate of 46%.

Interviews were conducted with people from the companies in the focus sectors in the province who were able to engage with a face to face meeting, or a telephonic interview. The process behind the selection was to be able to get a big picture of innovation and technology transfer in the province, so members from ancillary bodies such as funders and people who engage with business in the greater Western Cape as a whole. A total of nine interviews were conducted.

Further details of companies approached are as per the log in Appendix 15.4.

9.4 Data Analysis Methods

Qualitative data analysis is done according to the axial coding process outlined by Blanche et al. (2006), and casual loop diagrams are constructed as per Ryan (2011) to understand the linkages between the data and theory. The process whereby these diagrams are composed is as follows:
1. First level coding - This is the process whereby codes are extracted from the material which are relevant to the research question.

2. Second level coding – This process is the arranging of the codes into various themes which directly pertain to the research question.

3. Third level coding – This stage of the process involves the construction of an interrelationship diagraph. The diagraph identified drivers and consequential factors with regards to the themes formed in the second level coding process.

4. Fourth level coding – The drivers and consequential factors from the interrelationship diagraph are arranged so that the mechanism by which they operate can be established. This process allows for various interventions to added, in order to see how it affects the outcome in the appropriate context.

Information from the fourth level coding can then be used to propose recommendations, and draw conclusions against the research question.

Likert-scale data is used to form frequency graphs where applicable, and to give an indication of positive or negative perceptions in terms of the questions asked. These perceptions are discussed with the qualitative data received.

10 Research Findings and Discussion
The research findings and discussion begins with research around the characteristics of the Western Cape in the context of the problem area that is being researched. Following this, various themes that emerged from the coding process are presented and discussed with regards to the relevance to the research context, questions and the literature.

10.1 A Perspective of the Western Cape
Following a request of information from the various tertiary institutions in the province, data from the University of Cape Town reveals that only around 3% of the research contracts that the university engages in can be attributed to businesses that are domiciled in the Western Cape (See Figure 1).
If one looks at the province as a whole, there are disproportionately high levels of R&D that are done via public expenditure (25.11%), as opposed to private R&D expenditure (19.21%) (Figure 2). This is not the case in the province of Gauteng, where there are larger amounts of R&D that stem from private industry as opposed to public funded sources. These figures are not in lien with regard to the proportions of Gross Domestic Product (GDP) (3.61%) or population (10.30%) that are attributable to the specific region (Figure 2). This highlights the matter that it would appear that disproportionate funds are allocated to the province. However there are other demographic factors that need to be taken cognisance of when analysing the province, which would clarify this matter.

In relating the total R&D expenditure in the Western Cape (21.57% public and private) to the total patents generated in South Africa in the same year, being 13% (OECD, 2008, p.102), it appears that only a fraction of the research is distributed back into the province, whilst the rest is diverted elsewhere. This assumes that the bulk of the patents generated from this research are from private funding. Based on this one could assume that a similar problem is experienced at all the universities within the province, given the lack of specific data, and it also highlights the need to asses other factors which could influence this issue.
One of the reasons that is proposed to be responsible for the lack of private R&D funding in the province is the fact that the businesses that prevail in the province are not the type who generally partake in R&D (OECD, 2008). Companies who generally do partake in R&D are high tech companies by nature, as portrayed in Figure 3. This is relevant to this research paper as the barriers to business engaging with universities could quite simply be that there may be no economic need for them to do so. Therefore engagement on a provincial level needs to be done with specific partners identified for the identified research purpose.
So within the perspective and context of the Western Cape, it can be seen that the disparities with regards to funding can be attributed to business type and their subsequent interaction with universities in the province. This evidence reinforces the need to lower the barriers for companies to interact with universities in the province, so as to encourage provincial economic development.

10.2 Context of how Companies Source Technology
The topic of technology transfer and that of university-industry collaboration only gains relevance if one understands the context of how industry sources their technology. It implies that as there is no economic benefit and hence need for a company to engage with universities, this link may have little or no bearing to the study. Therefore an understanding of what universities can really offer to business is important so that the hurdles isolated can be adequately described within this context. Of the companies that were interviewed and which participated in the survey, the amount of interaction that they had with universities varied according to their proximity to the university, age and size of the company, and the amount of resources they had to manage the interaction.
The research found that R&D was usually driven from within the company – trickling down from the senior decision makers such as the Chief Executive, or Managing Director, and that R&D was a core function of the business and how they managed to stay competitive in their industry. This means that these personnel place the pressure on the R&D departments, or people that run the R&D function for the business, to pursue and develop marketable opportunities so that they can remain competitive within their industries. The majority of companies interviewed followed a market pull type of innovation process, where there was some sort of need, or scope for a need of a product in the field that was in question. This means that there is a strong requirement for the technology generated to be aligned with commercial and market requirements from the onset.

The sectors that were focused on (pharmaceutical, biotechnology, and medical devices) all require the acquisition and adoption of new technologies and products to maintain a profitable business. All of the operational companies that were interviewed preferred to look for these new R&D opportunities from within the company, rather than looking towards external sources to obtain technology. The rationale behind this lies in the easier management of the flow of information in the IP generation and the direction of the development of technology. Further to this it is noted that the younger the firm, the more potential it is bound to display with regards to interacting with universities in sourcing technology. The companies that did do this were primarily engaged with exploratory work at the universities, which is in line with findings of other researchers; Bercovitz & Feldman (2007); and Bonesso, Comacchio, & Pizzi (2011); and Laursen & Salter (2004). What is also interesting to note is that companies that tended to look to outside sources for new technology, generally preferred to use universities rather than other external sources (Bercovitz & Feldman, 2007) and this seems to hold across various sources. The research that noted this used the context of Italy, and its applicability to the context of the Western Cape and the comparability’s were not revealed in the data gathered for this research.

There are three phases of company growth that are identified with regards to interaction with universities. Each one of these has a general level of interaction that could be facilitated between the two parties. These phases that are identified and analogous to the Life Cycle model of company growth (Moore, 2004).
• Introduction/Entry stage – University interaction levels with this stage of company life are potentially high. This stage of growth is defined as the stage before technology traction is gathered, and the technology is being acquired or refined for the market at this stage. This phase is associated with disruptive, application and product innovation.

• Growth stage – this stage of a company life cycle is characterised by a company exploiting current technology before exploring new options for development (Stadler, 2007). This stage sees little potential for interaction with universities as exploitation of the current market is taking place, and process innovation is taking place on the product or service.

• Maturity stage – this is characterised by current technology reaching slower growth in the market. At this stage the company has acknowledged that the acquisition of new technology is vital to remain and grow in the business environment and experiential innovation usually takes place. At this stage there is ample opportunity for university engagement, as long as industry is enabled to do so, and there is not a negative perception of this interaction from within the company in question.

An important finding of this is that each of these businesses valued the resources that the university had available, and generally used universities in one form or another in the development of technology, even though this was largely done in house. This appeared to be the exception of the IT sector where the importance and the role of the universities are to provide skilled people to the industry that are able to assist them in the research work. This finding could potentially be limited by the small number of the IT industry sampled relative to the entire population.

This finding can potentially be attributed to the type of R&D resources that are required to develop and commercialise a product in the IT industry compared to that of the biotechnology industry. In the IT industry a start-up can be formed from relatively low infrastructure and financial input with the human capital being the most intensive resource, whereas a biotechnology company may require many specialised resources and hardware to get the technology to a testable and commercialised state. The case of a biotechnology start-up that was interviewed showed that the resources at the university’s disposal had proved vital in the development and growth of that company.
The core and most frequent interaction with universities related to the utilisation of specialised consultants in the fields that were relevant to the industry. The companies tended to value the general depth of knowledge available, but noted that specific knowledge was more difficult to come by due to the chosen fields that the departments would specialise in. This specialisation also means that there are specific departments which have a very good record of industry collaboration given the fact that they are aligned in certain areas which can be commercialised.

Of the companies interviewed which attested to collaboration with the university, one company noted that the formulation of an IP strategy was crucial to benefiting from their engagement with the university. This is in sync with literature, which states that the company needs to critically assess the risks involved in engaging in relationships involving publically funded research (Arza & Lopez, 2011). Hence a company needs to generate a focused and intentional research strategy to engage with universities, and the requirements that are placed on the technology. One of the strategic advantages that universities could offer companies, and which were revealed in the interviews, is that the university can give company’s guidance on an IP strategy and assist with patenting.

Various other forms of sourcing technology are as depicted in the Figure 4 below, as set out by the respondents. The research showed that 100% of the companies surveyed preferred to do technology development in house. Journals and literature also formed a crucial part of how companies sourced their technology (67% of companies). What was not revealed in the research is where the companies sourced literature and journals – the survey did not specify scientific journals, but since the companies are “high tech” and it is assumed that these journals are of a scientific peer reviewed nature. What backs this assumption up, is that the medical device sector is very reliant on public research (Genuis, 2005).

Conferences proved to be an important source of sourcing technology (50% of the surveyed companies) – from the interviews it is inferred that conferences proved to be an important source of market information or where it was felt that the market was heading. This then allowed the companies to produce a certain product, or align their technology development path to the market trends. Consulting firms also ranked as an important source of technology acquisition, however it cannot be distinguished whether these consulting interactions were those of university personnel. It is however noted that university consulting was the most
prevalent form of university interaction in this regard with 100% of respondents having used this form of collaboration in recent years (Figure 5).

![Figure 4 Manners in which companies source their technology in focus sectors](image)

### 10.3 Networks

The research found that many of the respondents relied on networks at various stages of their technology sourcing. These networks were related to the way that they sourced and linked various forms of technology.

Although not specifically linked to networks, one respondent to the question of how they managed to find the links with universities stated that “serendipity” played a factor in how universities and industry came together. This is with regards to the fact that the company was not out looking to find the link with the university, but rather through networks, managed to establish contact with a university department who was providing research in a specific area that they required work to be done in. This theme strongly links time, place and who is involved which bears a strong link to communication. This can be brought back to the fact that when one is out looking for opportunity, the opportunity may present itself. Directly related to this is the fact that these opportunities do not present themselves if one does not communicate with partners in industry.
Communication was cited as a factor that posed a huge problem to university-industry collaboration. This holds for all the role players within industry, particularly between the Triple Helix camps in the province. Communication serves as the direct influencer and primer of any link between university-industry collaboration. The main component of the lack of communication between the two parties is the lack of knowledge of what the other party is engaged in. This seems to be part of the problem between universities engaging in relevant research work, but could further be ascribed to the way in which the researchers choose their research topics. The relevance of this is covered in the section covering the relevant understanding of IP requirements between these two stakeholders.

A manner which attempts to bridge gaps between the university and industry is the formation of special purpose initiatives, such as the Cape Initiative in Materials and Manufacturing (Knutsen, Steyn, & Nicol, 2009). These initiatives are basically bridging networks aimed at communication between the role players in a sector, and although they do provide this, they also have challenges which they face with regards to financing. Therefore although these do provide a necessary bridge in the gap, it is questioned whether these types of models can be applied sustainably over a variety of sectors – perhaps a more sustainable type of solution should be sought that still allows for the networking and communication links that these provide?

10.3.1 Innovation as a People Driven Concept

A focus theme highlighted in the research is the manner in which technology is driven towards commercialisation. This can be attributed to the notion that a key team takes responsibility and devotes time and effort towards making the technology economically viable. This assumes that the technology has inherent potential to be commercially viable and adopted by the market. This is reinforced by the fact that many investors invest in an idea due to a strong team being in existence to take the technology to market, and to be able to deal with the challenges that may be faced along the way during this process.

Innovation is therefore highly reliant on the teams that play the role as the drivers of the process. The diversity and makeup of these teams is a requirement for them to be able to handle various situations in the context of a changing environment. Respondents to interviews therefore value that fact that universities have an aggregation of extremely
knowledgeable people on various subjects. This is assumed to be one of the reasons that consulting from university staff is one of the more popular low risk interactions with between universities and industries (See Figure 5).

Companies interviewed valued their links with universities through staff that furthered their education with masters’ research, which ensures that their links with universities are maintained. By maintaining this link, companies were able to stay abreast of technological advances in certain areas that were relevant to the business. This links directly to the communication of technological advances between groups, and it is evident that universities do play a major role in forming part of this link. The acknowledgement of the crucial importance of this link to business contrasts some of the perceptions that business has towards their view of the importance of the universities.

Figure 5 Industry’s previous interactions with university

Some companies that were interviewed shared the challenge of finding and recruiting knowledgeable people of a high calibre to the industry. This factor is envisaged as one of the most important roles attributed to the universities and was agreed to by all bodies interviewed, not only those within the focus sectors. This factor allows the companies to be competitive in their industries, and allow the knowledgeable people to use their skills to bring the company’s offerings to the market.
The scope of having the correct teams on board is potentially one of the largest barriers to allowing spin offs of university derived technology to be brought to the market. This is due to the fact that when technology is derived from university sources, there is usually not a team attached to that technology tasked with the aim of commercially viable success. Hence this may translate into a lack of skills in various areas and may not encourage investors to take on the risk relating to their investment.

10.4 Government Systems in Place to Assist

There are various manners in which assistance from government is offered with regards to funding of technology transfer and the commercialisation of technology from universities. These encompass funds that entitle companies to tax rebates which can aid cash flow for various companies. The financial support avenues that were discussed and used by the interviewees are as follows:

- THRIP – Technology and Human Resources Programme (THRIP) aims to provide pre-commercial research funding to companies and focuses on scientific research, technological development, and technology diffusion (DTI, 2011).
- TIPTOP - Technology Innovation Promotion through the Transfer Of People “is an incentive mechanism to encourage industry employees to further their studies while continuing their employment path” (THRIP, 2009, p.9). Costs are shared between THRIP and the industry partner involved.
- SPII - Support Programme for Industrial Innovation (SPII) “provides financial assistance for the development of commercially viable, innovative products and/or processes and facilitate commercialization of such technologies” (SPII, 2011, p.1).
- Innovation Fund - The innovation fund or Technology innovation Agency (TIA) aims to enhance the countries research into commercialised technology. Funding is granted to all sizes of industry and fledgling companies as appropriate (TIA, 2011).
- IDC – The Industrial Development Corporation is a development finance institution providing finance to all types of industrial development (IDC, 2011).
- SARS – The South African Revenue Services allows for tax rebates on scientific or technological research and development (SAICA, 2009).
The research indicates that these funds are utilised by the various companies to some extent. It appears that all companies had the knowledge of some of these funding and support structures, if not all of these. What is evident is that these systems really do enable young companies to benefit financially once it is understood how the mechanisms work and in which spheres they are applicable. The majority of the companies interviewed noted that the tax rebates with regards to R&D were the most frequently utilised benefit. Other companies also stated that they did not utilise the full range of funding mechanisms (other than the SARS rebate) as a result of the fact that the company did not qualify based on size – as many of the companies were found to be too large. Various early stage companies stated that they utilised the full range of funding mechanisms that were available.

The significance of availability of funding options to smaller companies is important, as small companies are economically agile and could create opportunities. If the perception exists that these funding mechanisms will stifle their growth, they will pursue alternative funding sources, or chose to grow slowly and therefore create fewer jobs over time. Another issue associated with some of these funding mechanisms is that companies that utilise them need to remain focused on the type of technology that they were funded for – even if that technology was no longer economically viable. This may imply that more agile companies are straight jacketed with regards to their strategic imperatives.

It is evident that some companies are wary of utilising the various government funding offered due to the fact that the grants come with limitations such as the existence of walk-in rights by government (IPR Act, 2008). This clause does not appeal to investors due to the perception that the technology, and the competitive edge of the company, may be detached from the company. On the other hand it does aim to protect the government and the universities from companies acquiring technology and not utilising it for strategic (or any other reasons) while there is the opportunity cost to universities of opportunities not being commercialised. This links in with the IP ownership section of technology derived from publically funded research, and definitely poses a barrier to technology transfer and in turn to the economic development of the region – even if the barriers are just a perception.

There have been a range of movements to develop various technology hubs in the region, with the aim of stimulating innovation. The parties interviewed were critical of these types of ventures as they did not really stimulate the formation of new technology, nor do they
provide real utilisable common services for the tenants. Although these initiatives are hugely successful in other areas of the world, a potential reason for their downfall in the local context could lie in their effort to stimulate a new form of industry, rather than develop and stimulate a sector that already had a strong economic presence in the area (Muro & Katz, 2010).

10.5 Conflict of Interest

A reason attributed to not engaging in research contracts with universities is said to be the conflict of interest between publishing findings relative to making a technology commercially viable (Myers, 2005). This was mentioned by one company interviewed, but the bulk of the other companies that were interviewed who did have students on research contracts did not experience this. This apparent ambiguity appears to be related to the manner in which control plays out between the company and the student. One company mentioned that they only engage with universities on the company’s terms – this implies that the students who are doing research contracts are usually in the employment of the company, and the direction of the research work is guided by the company’s commercial requirements. This does revert back to the requirements of the IPR Act – and research candidates under this type of program will need to be funded by the company. Hence the barrier may shift towards the cost of engaging in this type of relationship. By having the research student in full employ, the company can monitor and report regularly on the direction and progress of the work at hand. This means that one big hurdle of the university-industry interaction, monitoring and reporting on the work done, is removed.

Having stated the above, the company that is successful with this, also has students that further their research funded by the company, which does not contribute to the technological advancement of the company. This is done by the company as part of the on-going development and advancement of the staff within the company, which further increases their education, and as such makes business sense. This type of research is not fully funded by the company, only the students’ fees.

Completing and engaging research contracts at universities require management from within the company, as well as paying the full cost of the research. For smaller companies participating in this type of interaction, it may not be possible to allocate the manpower to
such a project, and therefore make it unfeasible. Reflecting back on the literature, it states that pharmaceutical companies usually participate in research contracts with universities due to the fact that it may be cheaper. One hypothesises of why this occurs could be that they have enough staff resources to oversee this and the time required to manage such contracts. What is seen here is in good agreement with the literature, where it states that smaller companies do not have the in-house capabilities, or financial readiness, to generate IP (Sawang & Unsworth, 2011).

10.6 Interaction of Students with Companies
Companies that were interviewed mentioned that there were instances of universities undertaking work for them, but that they did not understand the commercial importance of the service that they were performing. They identified that there was an inherent gap in the understanding of what type of work was required in the real world.

This gap is not a lack of professionalism, as highlighted by Fini & Lacetera (2010), as companies mentioned the services were received with a high calibre of professionalism. Rather it was due to the lack of knowledge of what businesses were required to do to put certain technology in practice to the market. This then led to a final product being semi-finished with regards to its commercialisation, which could also contribute to the perception of university research work being perceived as expensive.

The ability of the university to meet industry’s needs, and vice versa, is imperative to making university-industry collaboration working adequately. This is a key driver to leverage the large pool of information and talent available at educational institutions towards developing and stimulating regional economies. Further to this, there is a requirement for universities to understand how various IP generated could be scaled and commercialised. This relates to Myers (2005) who states that research transferability is key to the success of university-industry technology transfer.

This gap in the industry has led to evidence of there being industry perceptions of universities displaying an “Ivory Tower” mentality (Bremer, 1998) in the province. This perception relates to the notion that individuals within these institutions are not exposed to real world issues and pressures. Only through bridging this gap could a solution be found to the issue at
hand. In determining the cause of this perception, it is apparent that this seems reinforced by the lack of communication of needs between the two parties.

One of the interviewees stated in a seminar (Conference title: Stimulating university-industry and university-community engagement in Cape Town, held on 17 August 2011), which was not related to the interview, that academic programs in South Africa should make internships mandatory for students to complete degree programs. These internships, as required in other nations around the world, aim to prepare students for the requirements of the real world and manage their professional expectations. When these are done in fields related to courses, this could then prepare students to some of the key requirements that that particular industry may face. Further to this, it means that industry links would need to be regularly and formally maintained in order for the university to interact and to assist in securing these tenures for students.

Looking at this further, some companies noted that the training of students at their places of work was imperative to new recruits from university. These companies stated that they preferred to receive employees that had worked there on student vacations while at university, and as such maintained their accreditation with the government training body so that they were eligible for the benefits that this brings. This means that companies are able to get students in that are more ready for the job, and at the same time utilise this as part of their development program.

An interesting outcome of the research was that the bulk of the companies that had engaged in university interactions in the Western Cape had made use of the University of Stellenbosch. When probed as to why that particular tertiary education, the responses were that they had existing links to the university; or that they, or one of their employees, had attended the university at some time. This is an interesting facet of the research. This could be (as per the perception of the researcher) that the bulk of the people that study then remain located in the Western Cape and hence participated in the study, or there may be another unaccounted factor which makes this university “top of mind” in the greater industry community of the province. No information was found on open source channels to shed light on this and it is therefore proposed as a further avenue of research.

What this finding does underline is the preference of local industries (which were the focal point of the study) towards collaboration with universities that were in close proximity to
them. This is in line with the findings of the reference (Abramo, D’Angelo, & Costa, 2011), which states that the quality of work done in collaborations is higher when they are in closer proximity.

10.7 Culture
A regular theme that was mentioned in the interviews was that of culture – this theme was raised repeatedly and in light of various angles - all of which warrant some discussion. South Africans generally have been brought up with below average attitudes and perceptions towards entrepreneurship, which are required to give rise to the drive to start up entrepreneurial ventures (Herrington, J. Kew, & P. Kew, 2010). This means that as people develop professionally, they do not have the desire to create work opportunities for themselves. This in turn means that the majority of the people will require employment from whichever source that may be available to them. This carries on through to universities where there is an apparent lack of drive for students to take the next step to commercialise their intellectual work. This is further exacerbated by the fact that there are little, or seriously underdeveloped facilities and resources at hand to assist these students in crossing the gap between research work and something that could be commercialised.

Another point touched on regarding the socio-economic culture of South Africa is that there appears to be a lack of a culture of innovation in the country. This may be exacerbated by the fact that there is little R&D in the country’s businesses on average, and there is more of a propensity to imitate. This was also pertinently mentioned by one of the surveyed companies which recently underwent a change in leadership when the company was bought out by an international firm. The new managing director, from abroad, began to instil a culture of R&D in the company and oust the copying culture that they had before. An R&D team was employed solely to develop products which their market researchers identified a need across various international forums. It was mentioned that the change in culture was generally not well received in the beginning, but as time progressed employees began to witness the fruits of this strategy.

Culture was again identified with regards to the various funding mechanisms that were available to firms and entrepreneurs alike. These funding structures favoured opportunities where the outcomes were less risky, and where there was an almost guarantee of success.
Whilst this may sound logical, it may imply and indicate a culture that is scared to fail to make mistakes. If one takes the view of Design Thinking, failure early on in the process is good, as this failure enables one to learn from this and reinvent the product or process to be better and more resilient (Coughlan, Canales, & Suri, 2007). This type of risk-averse culture means that there seems to be wariness in supporting innovative technologies and new ideas, which does not help alleviate the issues around creating an entrepreneurial culture from a young age. While the researcher does not condone high risk frivolous lending, there should most certainly be more structures in place for young innovators to be able to identify the business risks and iron out some of the uncertainty that would make the idea more plausible.

Various other issues (other than the “Ivory Tower” mentality discussed previously) were identified in relation to the organisational culture that is present at universities. These are briefly discussed below, in the order of most pressing on the respondents’ minds to less so.

- Decision making abilities of the resources applied by the universities tended to be tardy, not proactive, and do not to appreciate the time constraints that industry required to get things done. This links in with the trait of accountability that enables the industry to perform its functions or simply, fail.
- Perceptions exist around the quality of work produced by universities – and that these are not on par with what is expected from the industry. This links in with the application of regulatory boundaries and standards that govern the work that the respondents did with the universities. However, this appears to be a minor barrier to university-industry collaboration as these tended to be project specific, resulting from a lack of communication with regards to the expectation between the parties and the terms of reference with regards the work that had to be done – additionally, as mentioned earlier, the general quality of work received from universities tended to be of acceptable quality. Furthermore there is a perception that the universities do not provide companies with on-going support after they have engaged in a service. This again ties in with a lack of communication between the parties in the terms of reference of the engagement and the boundaries thereof.
- Further impression of industry respondents regarding their collaboration with universities is that of arrogance, and the (in) ability of the university personnel to work with industry. This meant that the industry players could not adequately work
with their counterparts at universities, more specifically those of a higher qualification. Although this trait was mentioned, it is not elaborated on much as the instances that were reported tended to arise from the fact that the personnel did not fully grasp how this specific technology fitted into the marketplace.

10.8 IP Ownership
Potentially the biggest hurdle identified in working with universities was in relation to the IPR Act, and the consequences it causes with regards to ownership of IP that is generated from sources of public funds. The Act states that the ownership of the intellectual property resides with the university unless the costs that were used to generate the research are paid for by the commercial user (IPR Act, 2008). What this means is that firms engaging with universities in research contracts, are required to pay the market related cost to the university, for the resources that were spent during the duration of the engagement. This applies when a firm wants to retain ownership of whatever IP is generated, and this needs to be decided prior to the engagement.

Although this is not a hurdle per se, the research revealed that certain respondents felt that this caused research to be priced much higher than it needed to be. This contradicted some of the other interviewees who stated that research that they conducted through universities was done at a favourable price for the company, whilst no grants or rebates were applicable. A probable root cause of this dissatisfaction may emanate from the fact that the research may have been conducted at full cost, whilst the results were perhaps unusable. There was an occurrence of this mentioned, and companies preferred to have the researchers in the full time employ of the company to overcome this.

Public administrations have a key role in stimulating and supporting technology and IP generation (Segarra-Blasco & Arauzo-Carod, 2008). One key trend in the international field of innovation is the notion of innovation becoming more and more collaborative in nature, and that there seems to be evidence of more IP that was created with multinational participants (WIPO, 2011). This infers greater risk in the local context, as there may be greater policy and governmental interference, which could possibly lead to anti-competitiveness (Bouwers, 2011). As such, universities need to ensure that they are competitive with regards to the R&D and IP placed on offer. Despite this not always being
clearly measurable in terms of what the market will pay for it, this factor does needs to be taken into account.

11  Research Analysis and Recommendations

11.1  Interrelationship Diagraph

An interrelationship diagraph is constructed (level 3 coding) in order to ascertain which categories are antecedent or consequential factors of university-industry collaboration. The diagraph is described by Figure 6, where arrows indicate the inter-relationships amongst a range of factors that were identified and grouped in the coding exercise. The arrows between the various factors indicate direction to and from the factor. The factors with a greater amount of arrows outbound are driving factors, and those with the greater amount of arrows inbound are the consequential factors.

The relevance of identifying these is that it reveals which factors call for interventions in order to drive results and ultimately affect the system in a positive or negative manner.

Key drivers identified from the interrelationship diagraph are; communication, networks, conflicts of interest and understanding of government policies which may enable companies to engage in benefiting from the various funding programs that are available.
Figure 6 Interrelationship diagram
11.2 System Model

The system model gives a pictorial representation of the complexities that are present in the system of university industry collaboration. The intention of the system model is that it serves as an aid in understanding what needs to be done in order to develop countermeasures for the situation, within the context of the biotechnology, pharmaceutical and medical device industries.

Key factors identified on the interrelationship diagram are depicted on a systems model (coding level 4), or a causal loop diagram (Figure 7). This model describes the interaction amongst factors that drive interaction between universities and industry. Arrows depict the direction of the response when an intervention is applied, and these arrows are labelled with either an “S” or an “O”. “S” depicts that the response has a movement in the same direction (i.e. positive response of factor 1 gives a positive response of factor 2), and “O” depicts that the response has movement in the opposite direction (i.e. positive response on factor 1 gives a negative response on factor 2). The various coloured arrows depict the various different routings that the mechanisms may follow.
Figure 7 System model of University-Industry Collaboration
11.3 Primary Mechanism

The primary feedback loop identified in the system is that of communication and interaction between universities and industry (Figure 8). The theme of communication is a common driver that is present both in the interviews and threads through as an underlying theme for university-industry collaboration in the literature. As such it is chosen as the primary driver for the system.

Figure 8 Mechanism 1- Primary Causal loop (Part of overall system diagram-Figure 7)

A system intervention (which is depicted in the model to improve university-industry interaction) is the setting up of a communication platform such as a blog or a newsletter. This was noted by one of the participating companies which took part in the research, and is also a method employed by the successful Massachusetts Institute of Technology (MIT), TTO to enhance collaboration with business (OECD, 2008). This newsletter could be distributed amongst companies who in turn pay a membership fee, and in return get access to specialised information. The newsletter will a tailored offering to their specific sector interests, a directory of research, and extent various opportunities to network with university staff (which ultimately results in a consulting engagement with the university). These networks are cited
by Nikulainen & Palmberg (2010) to be crucial in forging relationships and a channel of knowledge between university employees and industry players.

What is interesting about the notion of a potential portal for an industry to access specialised information that is pertinent and relevant - is that journals and literature are one of the core avenues that companies use to source new technology (see Figure 4) – if this type of information link is formed, it will most certainly be beneficial to industry partners.

Focused communication to industry players by universities remains part of the countermeasure which calls for strategic relationships developed by universities to the various sectors. The degree to which this may be applicable depends on available resources and the capacity of industry to want to engage with the universities. The basis of the strategic relationship lies in the inception of the new IPR Act, which has redefined the universities’ role in innovation. An outcome of the IPR Act is that universities are now required to become more actively involved in the innovation process within a company. This is due to the fact that there may be an on-going relationship between industry and the university due to licencing of technology or shareholding that the university may have acquired. This redefinition of role-players means that universities need to position themselves as a competitive industry and position and partner within strategically focused industries where there is sufficient scope for collaboration.

While it is understood that limitations exist with regards to manpower to manage such interventions, and while assuming that companies are willing to pay for such a service, this does specifically act on the drivers of communication and networking within the system – ultimately strengthening the ties.

11.4 Secondary Mechanism

The secondary mechanisms, or the secondary causal loops, are identified by the secondary factors which drive the outcome (Figure 9). The perception of the IPR Act plays a hindrance for people wanting to engage with universities. This factor seems to be both due to companies not understanding how to work with it or with the funding mechanisms that that are available through public sources. What this does is create the perception of increased cost when dealing with universities. If it assumed that universities position themselves competitively
with regards to their pricing, and that there are no obviously cheaper means of doing R&D, then one means for a company to gain benefits from the universities is to choose how they strategically engage with them in their activities. The choice of engagement with the university will also give the company more control on their IP generation. Quatraro (2009), states that publically funded research can be a competitive advantage. With this in mind, if companies chose to engage and strategically adopt this advantage then there is potentially great benefit to be reaped from the collaboration. This echoes the sentiments of some of the companies interviewed, who state that their companies would not be present if it were not for university generated information.

Figure 9 Mechanism 2- Secondary Causal loops (Part of overall system diagram-Figure 7)

In the realm of education, a multi-pronged response is required. Initially, education is required at a grassroots level. This type of education needs to instil a sense of entrepreneurship into young people when they are at an early stage in the education system. This means that as people develop in the educational system (right through to tertiary institutions), they will be able to more fully seek and take hold of opportunities as they
present themselves. It also implies that they may be better equipped to identify these opportunities as they present themselves. Although this is a rather lofty task, which may take many years to filter through and be felt in society, it will result in a change in the manner in which people choose to pursue opportunities and careers. Furthermore, the very definition of opportunities worth pursuing may change. Once the desire exists to fully grasp an industry’s needs and to develop this need into something practically useful (even if this is just a skillset), it will ultimately create a pathway for people within tertiary industries to foster this linkage to industry.

The other prong of education is of a far more simplistic and practical nature - which links in closely with communication. This relates to a simple news/information front which is easily accessible by industry and showcases the utility of their systems, processes and the general engagement process within the university research process. This type of intervention, which could possibly rolled out as a case study, will aid in the education of the direct users and a base of potential research clients to ultimately alter perceptions around interacting with universities, which may include concerns around high costs or the lack of professional standards. This again assumes that this is practically possible due to the diverse nature of the interactions that may take place, and there would most certainly be limitations with regards to confidentiality of information.

11.5 Analysis Summary
The following summarises the interventions that are that are isolated in the system model that are applicable in the context of this study. The outcome of these interventions is to improve the environment for industry to interact with universities.
<table>
<thead>
<tr>
<th>Intervention</th>
<th>Mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blog, newsletter, or case study</td>
<td>Increasing communication between parties, and allows for sector networks to be built up</td>
</tr>
<tr>
<td>University creating strategic links with industry</td>
<td>Increasing communication between parties, and allows for sector networks to be built up – allows for specific markets to be targeted with regards IP generation and costing</td>
</tr>
<tr>
<td>Companies engaging strategically with universities</td>
<td>Increases control of IP generation, and exposes students to industry. This engagement should decrease the overall cost of engagement if the company develops a strategy to involve the university in their IP generation</td>
</tr>
<tr>
<td>Ensuring university research competitiveness</td>
<td>IP generation at universities needs to be competitive with regards to cost and availability – this decreases cost of acquisition resulting in more company control of their IP generation</td>
</tr>
<tr>
<td>Instilling entrepreneurship as a theme in the South African education system</td>
<td>Education drives innovation from providing and avenue for industry experience, and by educating industry of facilitative measures available to them in acquisition of IP</td>
</tr>
</tbody>
</table>
11.6 Research Limitations

A major limitation to this research is the timeframe and the limitations around the extent of datasets available from third parties within the due dates. Various sources have undertaken to still supply the data requested, but only subsequent to the submission date for this report. Further to this, in certain instances institutions were unwilling to reveal some of the data that was requested – based on confidentiality.

Various respondents to research instruments in this research were selected according to their involvement in the industry, and surveys were not sent randomly to all employees in the selected organisation. This is because of the very specific nature of the R&D function within an entity. This means that there may be bias in the data gathered from these respondents, potentially reflecting views from the perspective of only one project, or that employee’s time or tenure at the business. To try and minimise the effects thereof, the researcher attempted to attain more than a single individual from the various industries to comment, but this was not always possible due to the small size of the businesses approached – i.e. an inherent sector characteristic bias.

The limitation with the questionnaires is that the respondents may have interpreted the survey questions in different ways. To try and minimise this form of bias, a number of one on one interviews were conducted. Data generated by the research instruments was checked according to criterion, content and construct validity. Validity was checked within the context of the data received and all efforts to avoid subjective analysis were taken in this regard.

One of the limitations of this research is that of the selection for the IT sector to gather results. This is due to the fact that there is not an adequate sample of the IT sector in the this research to adequately justify the conclusions of this sector – this is a shortcoming due to the limitations on time and the number of companies that were able to be approached. Although there are some instances where there were interesting findings from this sector where it could be assumed that these represent the views of the entire sector – these are noted as such.

The context of the research also included that of the pharmaceutical industry in the province; however an interview was not secured with any pharmaceutical company. This means that some of the results are applicable to that sector, but caution must be taken to generalise these results to that of the entire sector in the province.
While parts of this research may be applicable in other contexts such as other provinces and other countries, caution must be taken to take into account due with regard to the influence of local economic factors that are unique to the region of the Western Cape. These findings may not be transferred to other sectors, even within the same province, due to the fact that the R&D requirements for the focus industries may differ significantly from alternative industries.

12 Research Conclusions

The goal of this research process was to clarify some of the posed research questions in the defined scope of the study. The particular questions are answered individually (see below), where the bold italics represent the research questions posed.

Main research question

What are the underlying mechanisms which pose the hurdles for successful technology transfer and innovation?

Various hurdles to university-industry collaboration were highlighted in the research, the most important of which is that of communication between the two parties. There are many perceptions related to interaction between the two parties. The main hurdles for university-industry collaboration identified are communication, conflicts of interest, perceptions around the IPR Act, culture and the control of IP generation. As should communication between industry and universities gain traction and evolve into a facilitative nature, these hurdles could be overcome in time.
Research Sub Questions

What is the current level of university-industry interaction in terms of technology acquisition?

There are three phases of company growth that are identified with regards to interaction with universities. Each one of these has a general level of interaction that could be possibly done between the two parties.

- Introduction/entry stage– University interaction levels with this stage of company life are potentially high.
- Growth stage – This stage sees little potential for interaction with universities as exploitation of the current market is taking place.
- Maturity stage – At this stage there is ample opportunity for university engagement, as long as industry is enabled to do so, and there is not a negative perception of this interaction from within the company in question.

What are the key avenues through which companies in key sectors source their technology, and how important is the acquisition of new technology perceived to be for their core business?

The importance of technology acquisition to a company’s business can be likened to the model presented in the answer to the previous question. The limitation lies in the particular technology in question which may not have any marked competition pressures requiring progress or innovation.

The key avenues that companies source their technology through are as follows: In house need identification (through client needs identification or in house development); conferences; journals and literature; and consulting firms.
How aligned are universities to meeting the technology needs of industry in the selected sectors?

Technology acquisition from previous engagements with universities has proved to be beneficial to the sectors analysed. The companies that engaged in the research also indicated that there is potential for universities to assist in technology acquisition in the future. This result was ambiguous in the sense that whilst further pursuing this questioning to gauge whether they perceived universities to have access to the resources (to meet the needs of the company) these companies displayed greater reservation and apprehension relating to future engagements with universities. In summarising the evidence, it appears that industry acknowledge that universities play a significant role in their future business growth, but that perceptions do exist which create reservations around pursuing these opportunities.

What needs to be done to improve communication of needs and products between stakeholders?

Current suggestions at improving the communication between the various parties include the establishment of a blog or a regular newsletter, or even a case study overview of how companies can practically engage.

What are the enablers and barriers to technology diffusion and communication of these needs between parties?

The biggest barrier to technology diffusion identified in the research is that of the constraints that companies perceive the IPR Act puts onto technology funded by publically funded research. This means that there is a perception created around the high cost of this technology, and once licenced the risk lies in the usage of this material as a competitive edge and ultimately being disenfranchised as and when the licence is revoked.

What is government actively doing with regards to assisting the current situation?

Government has currently implemented action by instituting the IPR Act. This increases universities exposure in the arena of innovation generation from merely a platform from which to do cheap technology development, to a position where they become active partners in the process. The changing roles of universities in this process means that both universities
and industry need to develop a strategic plan by which they interact with each other so as to make these interactions more fluid and mutually beneficial.

*Are there breakthrough technologies that could influence industries in developing sectors in the region?*

The research did not identify any particular areas in this regard, given the fact that companies treat these developments with utmost confidence. There were instances of companies who were in the process of approaching universities in light of pursuing some of these options, and others who were currently actively involved in the development of technologies with universities.

*What will be the sorts of collaboration gaps that might need to be filled in future?*

There is a definite need for both universities and companies to strategically engage with one another in collaboration. The universities have resources, both hard and soft, that are extremely valuable to business in the province – strategic alliances need to be formed and competitively maintained as to the benefits of both parties.

*By enhancing enablers, or overcoming barriers to technology diffusion, how will this improve the status quo?*

The study of university-industry collaboration is a complex subject spanning economics and social sciences, and involving all spheres of society. The intention of providing countermeasures to the barriers posed, attempts to improve the chances of businesses using universities as a partner in their R&D, and in turn generating economic benefit to the region. There are many other factors that need to be in place for this to occur, but these countermeasures can give the players a better chance at making collaboration beneficial to all involved.
12.1 Closing Words

Universities have a clear and very important role in the framework of the national economy, and more importantly in that of the regional economy where they are based. The role of universities is evolving from a supplier of technology in industry to that of a partner in technology development and implementation. Universities are still potentially a valuable and cost effective source of technology for business, and as such both parties need to relook at their engagement with one another so that the maximum amount of value can be drawn from the relationship. In assessing this strategic engagement of university-industry collaboration countermeasures to the barriers which negatively influence the interaction need to be implemented. Although this new relationship is in its developing stages and much positive collaboration is taking place, the future holds scope for many more.

13 Future Research Directions

A potential further research area could be to analyse where university entrants generally come from when commencing research work and where they distribute to after studies have been completed. If this is done from within universities, or their alumni relations, it could possibly aid better understanding towards how universities may be affected by the “top of mind”, alma mater factor that one feels for the university attended.

Companies in Italy who source technology from external sources tend to look towards universities before other partners are considered (Bercovitz & Feldman, 2007). A possibility for further research is to compare the policy and environment for university industry interactions between Italy and South Africa, and compare whether analogous findings can be drawn.
14 References


Hippel, E. V. (2002). Horizontal innovation networks - by and for users. MIT Sloan School of Management.


15 Appendices

15.1 Questions for Interviews

- What proportion of revenues has you company spent on R&D over the last five years?
- What type of innovation activities have been implemented at your company in the last 5 years? What type of innovations are these – market push, or market pull?
- How do your company’s investments in innovation compare with its other investments?
- Are you satisfied with your investments in innovation? How is their success measured?
- Who drives innovation and technology acquisition at your company? Do they have contacts at universities with whom they deal in this acquisition process (consulting or other)?
- What do you perceive to be the biggest barriers to university-industry collaboration at your company?
- What type of university-industry collaboration types does your company participate in?
- How does your company source new technology? Does this come from internal means, or external?
- What role does the government and/or their policies play in your company’s acquisition of technology? (ie. Taxes, rebates and grants, IDC, etc.)
- Have you had experience of university industry collaborations in the last five years? Were your expectations met in terms of how it was carried out? [elaborate if both yes or no] Would your company consider participating in this type of collaboration again? Why?
- What measures/interaction would encourage your company to participate further with university aligned interaction? [elaborate on type of technology or interaction]
- Where does your company look for new technology? {i.e. Do not source externally, internet search, trade magazines, university contacts, conferences, technology vendors, science councils, overseas firms (operating companies), local firms, journals/literature consulting firms, R&D firms, other}
• Are there breakthrough technologies that are required to remain competitive in your industry?
• If you do collaborate with universities – how do you find out about the available technology they offer, and how this fits into what you want to achieve?
• Are there any further relevant pieces of information that you think may be pertinent to this study, or aid in university industry collaboration?
### 15.2 Electronic Questionnaire

1. What industry does your company operate in?

   View responses to this question  
   Total Respondents 6

2. What proportion of revenues has your company spent on R&D over the last five years?

   View responses to this question  
   Total Respondents 4  
   (skipped this question) 2

3. On-going innovation and technology acquisition is important to our company to stay competitive in the industry?

<table>
<thead>
<tr>
<th>Response</th>
<th>Total</th>
<th>Response Percent</th>
<th>Points</th>
<th>Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>5</td>
<td>83%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Slightly agree</td>
<td>1</td>
<td>17%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>No Position</td>
<td>0</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Slightly disagree</td>
<td>0</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>0</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>
   Total Respondents 6

4. Our company generates our own technology rather than looking to outside sources

<table>
<thead>
<tr>
<th>Response</th>
<th>Total</th>
<th>Response Percent</th>
<th>Points</th>
<th>Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>3</td>
<td>50%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Slightly agree</td>
<td>2</td>
<td>33%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>No position</td>
<td>0</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Slightly disagree</td>
<td>1</td>
<td>17%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>0</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>
   Total Respondents 6

5. Universities have the resources to meet the needs of our company’s technology needs

<table>
<thead>
<tr>
<th>Response</th>
<th>Total</th>
<th>Response Percent</th>
<th>Points</th>
<th>Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>1</td>
<td>17%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Slightly agree</td>
<td>3</td>
<td>50%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>No position</td>
<td>1</td>
<td>17%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Slightly disagree</td>
<td>1</td>
<td>17%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>0</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>
   Total Respondents 6
6. Interaction with universities has proven to be beneficial to our company in recent years

<table>
<thead>
<tr>
<th></th>
<th>Response Total</th>
<th>Response Percent</th>
<th>Points</th>
<th>Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>2</td>
<td>33%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Slightly agree</td>
<td>2</td>
<td>33%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>No position</td>
<td>2</td>
<td>33%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Slightly disagree</td>
<td>0</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>0</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Total Respondents 6

7. Government policies assist our company adequately in the interactions with universities (eg. tax deductible fees etc.)

<table>
<thead>
<tr>
<th></th>
<th>Response Total</th>
<th>Response Percent</th>
<th>Points</th>
<th>Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>1</td>
<td>17%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Slightly agree</td>
<td>2</td>
<td>33%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>No position</td>
<td>1</td>
<td>17%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Slightly disagree</td>
<td>2</td>
<td>33%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>0</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Total Respondents 6

8. There is potential for universities to provide our company with technology acquisition in the future

<table>
<thead>
<tr>
<th></th>
<th>Response Total</th>
<th>Response Percent</th>
<th>Points</th>
<th>Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>2</td>
<td>33%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Slightly agree</td>
<td>3</td>
<td>50%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>No position</td>
<td>1</td>
<td>17%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Slightly disagree</td>
<td>0</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>0</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Total Respondents 6

9. Please state which modes of university technology transfer your company has been involved in recently (you may select more than one option)

<table>
<thead>
<tr>
<th></th>
<th>Response Total</th>
<th>Response Percent</th>
<th>Points</th>
<th>Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>General (eg. conferences, publications)</td>
<td>3</td>
<td>50%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Focused (eg. consulting, research contracts)</td>
<td>6</td>
<td>100%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Training (courses offered at universities)</td>
<td>1</td>
<td>17%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Intellectual property (patents, licensing, sale of IP)</td>
<td>2</td>
<td>33%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Other, please specify</td>
<td>0</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Total Respondents 6

10. Where does your company look for new technology?
<table>
<thead>
<tr>
<th>Source</th>
<th>Response Total</th>
<th>Response Percent</th>
<th>Points</th>
<th>Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>In house development</td>
<td>6</td>
<td>100%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Internet search</td>
<td>1</td>
<td>17%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Trade magazines</td>
<td>1</td>
<td>17%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>University contacts</td>
<td>1</td>
<td>17%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Conferences</td>
<td>3</td>
<td>50%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Technology vendors</td>
<td>1</td>
<td>17%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Science councils</td>
<td>0</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Overseas firms</td>
<td>0</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Local firms</td>
<td>1</td>
<td>17%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Journals/literature</td>
<td>4</td>
<td>67%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Consulting firms</td>
<td>2</td>
<td>33%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>R&amp;D firms</td>
<td>0</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Do not source externally</td>
<td>0</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Other, please specify</td>
<td>0</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Total Respondents: 6

11. What do you perceive to be the biggest barriers to university-industry collaboration at your company?

View responses to this question
Total Respondents: 6

12. Are there any further relevant pieces of information that you think may be pertinent to this study, or aid in university-industry collaboration?

View responses to this question
Total Respondents: 3
(skipped this question) 3
15.3 Data requested from Higher Education Institutions

- What are the key industries (and industry sectors) that your institution focuses on with regards to university-industry collaboration in the Western Cape?
- What percentage of all contract research is conducted in the Western Cape?
- What forms of university-industry collaboration are generally targeted? (specifically around conferences, consulting, contract research, joint R&D projects, training, and the sale of intellectual property)
- Value of each of the above interactions with the university analysed according to regions and industry sectors.
### 15.4 Meeting list and list of contacts

<table>
<thead>
<tr>
<th>Company</th>
<th>Interviewed</th>
<th>Sent Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synexa Life Sciences</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Vision Biotech</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biovac</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Bioclones</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>BBI Enzymes</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Fine Chemicals Corporation</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Prime Pharma</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Anmarate</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Gabler Medical Devices</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Fibretek</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Diacoustic</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Presbivision</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Germopulse therapy</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>SM Specialist Solutions (Pty) Ltd</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Caperay</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Antrum Biotech</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Accelerate</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>ODA</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Siliconcape</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>UCT RCIPS</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
15.5 Types of University-Industry collaboration
(Bekkers et al., 2008, p.1843)

- Scientific publications in (refereed) journals or books
- Other publications, including professional publications and reports - Participation in conferences and workshops
- Personal (informal) contacts
- University graduates as employees (B.Sc. or M.Sc. level)
- University graduates as employees (Ph.D. level)
- Students working as trainees
- Flow of university staff members to industry positions (exc. Ph.D. graduates)
- Staff holding positions in both a university and a business
- Temporary staff exchange (e.g. staff mobility programmes)
- Joint R&D projects
- Contract research (excl. Ph.D. projects)
- Financing of Ph.D. projects
- Consultancy by university staff members
- Personal contacts via membership of professional organisations
- Personal contacts via alumni organisations
- Contract-based in-business education and training delivered by universities
- University spin-offs (as a source of knowledge)
- Specific knowledge transfer activities organised by the university’s TTO
- Sharing facilities (e.g. laboratories, equipment, housing) with universities
- Patent texts, as found in the patent office or in patent databases
- Licenses of university-held patents and ‘know-how’ licenses