Commercialization of University Innovation in South Africa

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The financial assistance of the National Research Foundation (NRF) towards this research is hereby acknowledged. Opinions expressed and conclusions arrived at, are those of the author and are not necessarily to be attributed to the NRF.

Commercialization of University Innovation

in

South Africa

Submitted in fulfillment of the requirement for the degree of
Doctor of Technology: Public Management
Faculty of Management Sciences

by

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Declaration

I, Ramika Bansi, hereby declare that this thesis is the result of my own investigation and research and it has not been submitted in part or in full for any other degree or to any other University

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March 2016

Acknowledgement

I express my sincere appreciation to those who have contributed to the successful completion of my study:

Prof N. Dorasamy & Prof G. Harris for supervision and guidance. To Prof K. Reddy for his constant encouragement and motivation during my study, and for teaching me the art of research. Deepak Singh for the statistics.

My parents, for stressing the importance of education.

Shivam, Vyal & Thiru the love and strength of my life ~ thank you for your tolerance and support during my study.

Dedication

I dedicate my study to:

My grandfather, **Ramkisun Bansi** & my dad, **Krishna Bansi** for teaching me that failure is the first step to success

My brother, **Bisham Bansi** for being that constant in my life

Vyal Mrinal, **Shivam Mayur** & **Thiru** the anchor in my life and for bearing the brunt of my love, care and affection - your existence have been my guiding beacon in all my endeavours

An innovation's inherent value
is only acknowledged within its environment
when the manifested outcome such as a commercial product
is utilized by the public

Abstract

Globally, commercialization of university innovation has increased and gained in interest by universities, industry and politicians. The idea of marketing innovation produced by universities is the practice embraced in most advanced economies. However, government's investment in R&D have not generated the anticipated return. A gap has been identified between innovation developed from publicly financed research and the failure to convert these findings into tangible outcomes.

This thesis reports on an investigation of the reasons for the current low rate of commercialization of innovations at South African universities, with a view to increasing this rate. From a survey of intellectual property and technology transfer (IP&TTO) managers and interviews with individual innovators, the main contributory factors were found to be a lack of support from university management, insufficient incentives for innovators, limited access to funding opportunities, institutional bureaucratic regulations and an inefficient system of decision making with regards to intellectual property.

Accordingly, the critical measures which can be modified in order to build university IP&TTO success are senior executive support for innovation and commercialization activity, a greater share of financial rewards to individual innovators and a streamlined decision making procedures concerning intellectual property assets.

University, government and industry executives need to demonstrate genuine support for research and innovation development activity over the long term, allocate the necessary resources required for its success, and implement a long term strategy for intellectual property.

List of Acronyms

AIA	-	America Invents Act
ARC	-	Australian Research Council
AUCC	-	Association of Universities and Colleges of Canada
AUTM	-	Association of University Technology Managers
BEE	-	Black Economic Empowerment
BIS	-	Business, Innovation and Skills
BITBM	-	Bachelor of Innovation Technology in Business Management
CECR	-	Centres of Excellence for Commercialization and Research
CFS	-	Canadian Federation of Students
CIPC	-	Companies and Intellectual Property Commission
CIPRO-	-	Companies and Intellectual Property Rights Office
CRC's	-	Co-operative Research Centres
CSIRO -	-	Commonwealth Scientific and Industrial Research Organization
DACST	-	Department of Arts, Culture, Science and Technology
DHET	-	Department of Higher Education and Training
DOE	-	Department of Energy
DPSA	-	Department of Public Service and Administration
DST	-	Department of Science and Technology
DTI	-	Department of Trade and Industry
DVC	-	Deputy Vice-Chancellor
EPIC	-	Engineering Portfolio of Inventions for Commercialization
FDI	-	Foreign Direct Investment

GDP	-	Gross Domestic Product
GDS	-	Growth and Development Strategy
HESA	-	Higher Education South Africa
IDC	-	Industrial Development Corporation
IP	-	Intellectual Property
IPP	-	Innovation Policy Platform
IP&TTO	-	Intellectual Property and Technology Transfer Office
MIT	-	Massachusetts Institute of Technology
MTA's	-	Material Transfer Agreements
NHMRC	-	National Health and Medical Research Council
NIPF	-	National Industrial Policy Framework
NIPMO	-	National Intellectual Property Management Office
NPM	-	New Public Management
NRDS	-	National Research and Development Strategy
NSI	-	National System of Innovation
OECD	-	Organization for Economic Co-operation and Development
PCT	-	Patent Co-operation Treaty
PFIP	-	Public Funded Intellectual Property Bill
PSRE	-	Public Sector Research Enterprises
R&D	-	Research and Development
SACRO	-	South African Companies Registration Office
SAPTO	-	South African Patents and Trade Marks Office
SET	-	Science, Engineering and Technology
SETI's	-	Science Engineering and Technology Institutions
SPII	-	Support Programme for Industrial Innovation
SRISHTI	-	Science, Research and Innovation System for High Technology in India

SSDU	-	Specialised Service Delivery Unit
STI	-	Science Technology and Innovation
THRIP	-	Technology and Human Resources for Industry Programme
TIA	-	Technology Innovation Agency
TLO	-	Technology Licensing Organization
TRIPS	-	Trade Related Aspects of Intellectual Property Rights
TTO's	-	Technology Transfer Offices
TYIP	-	Ten-Year Innovation Plan
USA	-	United States of America
USPTO	-	US Patent and Trademark Office
WIPO	-	World Intellectual Property Organization
WTO	-	World Trade Organization

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Chapter 1
INTRODUCTION

1.1 Introduction

The knowledge based economy indicates that research, development and innovation are fundamental prerequisites for achieving and maintaining competitiveness and sustained growth. In an increasingly innovative global world, the ability to invent, design and manufacture goods and services that people want is more vital than ever for our future prosperity. Higher education institutions worldwide have realized the importance not only of generating new knowledge through research and development programmes, but also actively participating in applying and utilizing the knowledge and technology for new products, processes and services (Du Pré 2009: 3). The stimulation of technology transfer and commercialization of technology contributes towards important benefits for economic development in countries such as South Africa. One of the ways in which this can be achieved is through the commercialization of university innovation. Discoveries at universities derived from research often result in innovation with potential value. Valuable intangible creations of the mind are referred to as intellectual property. The creations, expressions and products that are derived from knowledge are afforded rights which are protected by intellectual property law. There are various forms of intellectual property such as patents for innovations and discoveries; copyright for original expression; trademarks to distinguish a name or symbol from another; and trade secrets for information held from the public to give the originator/inventor a competitive advantage over another person.

Universities all over the world have increased their engagement in technology transfer and commercialization of academic research. This development has been promoted by government policies and initiatives seeking to increase the extent of research commercialization (Callan 2009: 17; Rasmussen and Rice 2008: 3). With universities being one of the primary sources in the generation of innovation, they play an increasingly crucial role in the process of technological innovation, technology transfer and commercialization of intellectual property (IP) arising from research activities that ultimately contribute to national economic and social development. Aside from each country's national innovation framework, however, important strategies must be implemented at the institutional level for the successful commercialization of IP to occur (Rice 2012: 166). These elements include an adequate IP infrastructure, incentives to support technological innovation, and the necessary expertise to manage IP through the protection and commercialization processes. Should these elements not be in place, success in commercialization may not be possible. The consequence of this will result in the university not being able to exploit its IP assets for commercial gain.

This chapter outlines the main themes experienced by universities in an effort to contribute towards sustained growth and to compete in the global economy, which has provided the motivation and objective for this study. The study investigates methods to improve commercialization efforts to bridge the gap between academic research and commercial application. The commercialization process at universities is faced with obstacles, challenges and a fair number of associated risks that contribute to the uncertainty of its success. Given the apparent success of research organizations in the United States of America (USA) and other countries exploiting their IP, the question has been raised as to why the rate of commercialization at South African universities remains so low. This study seeks to answer that question. This chapter further analyzes the key concepts and definitions the research used in the research methodology.

1.2 Definition of key concepts

Innovation, technology transfer and commercialization concepts encompass different interpretations and views, depending on the organizations' objectives, the research areas and disciplines within underlying theories. Various parties are therefore likely to hold different views and perceptions on these concepts. According to Wahab, Rose and Osman (2012: 69) different perspectives and theories underlying technology transfer will have different theoretical arguments, insights, research problems, constructs, variables and measurements. The lack of a generally agreed upon definition of innovation has contributed to significant confusion, thus making it challenging to pursue constructive discussions. A discussion of concepts in the context of this research study is therefore useful for the understanding of the investigation that follows.

1.2.1 Innovation

Innovation distinguishes between a leader and a follower. Furseth, Cuthberston and Reynolds (2011: 1) affirmed that successful innovation is driven by the value created, and ultimately it is the customers who define the value of innovation. Kumar (2013: 1) explained that innovation is a viable offering which is new to a specific context and time, creating user and provider value. Innovation is the management of activities involved in the process of idea generation, technology development, manufacturing and marketing of a new or improved product or manufacturing process (Trott 2012: 15). According to the United Kingdom Department of Trade and Industry (2007: 6) innovation is the successful exploitation of new ideas.

Selfano (2014: 1) argued that for an idea to be called an innovation, the idea must be replicable at an economical cost and must satisfy a specific need. Innovation involves the deliberate application of information, imagination and initiative in deriving greater or different value from resources, and encompasses all processes by which new ideas are generated and converted into useful products. Sartori, Favretto and Ceschi (2013: 2) outlined in the Oslo Manual (published by the Organization for Economic Co-operation and Development (OECD)), that innovation is the implementation of a new or significantly improved product (good or service) or process, a new marketing method, or a new organizational method in the business practice, workplace or external relations of a company.

Marketing innovations are better understood as being aimed at addressing customer needs, opening up new markets, or newly positioning a firm's product on the market, with the objective of increasing the firm's sales (Organization for Economic Co-operation and Development 2005: 49). While the commercialization and innovation processes are interdependent, it is nevertheless necessary to distinguish the difference between them (Andrew and Sirkin 2007: 5). Commercialization has more to do with taking research and development from the laboratory to the stage where it can find application in an industrial setting. Using this know-how to develop a new product would therefore be considered as innovation (Cornford 2008: 7).

1.2.2 Technology transfer and commercialization

Two concepts that are closely related are 'commercialization' and 'technology transfer' (Zhao 2004: 227; Harman and Harman 2004: 155). These concepts are also referred to as technology diffusion. The process through which new innovation is transferred from universities to the marketplace requires attention to ensure the desired results are achieved for economic growth and competitiveness. According to the Innovation Policy Platform (2014: 1), the process of effectiveness has a substantial impact on the contribution to economic development and calls for awareness regarding: i) its process and the key individuals involved; ii) the conditions that enable such processes; iii) the factors that affect the demand for it; and iv) the rationale and means of policy intervention.

1.2.2.1 Technology transfer

Srinivas (n.d.: 4) postulates that technology transfer is defined as a process for conceiving a new application for an existing technology. It is also defined as a process for converting research into economic development. The noun ‘technology’ is simultaneously used to mean concepts, descriptions, components, processes and products. The verb ‘transfer’ is understood to mean moving from one point to another. Technology transfer therefore refers to the movement of know-how, skills, technical knowledge, procedures, methods and expertise from one organizational setting to another (Roessner 2009: 2). The term commonly refers to the transfer of assets from research institutions such as universities to industry or a type of manufacturing environment to generate economic value, thereby increasing industry development. Technology transfer can also occur when industry obtains technology from an external source, for example a university, government laboratory, another industrial corporation, or an individual (Reamer, Icerman and Yotie 2003: 17). Reamer *et al.* (2003: 18) further argued that all new innovations are built on existing knowledge. Technology development often depends on scientists and engineers knowing about and having access to good ideas, and the previous discoveries of other researchers. The greater the extent of knowledge and access to previously researched work, the more likely new technologies that are developed can be the basis of future successful products. Srinivas (n.d.: 4) attested that technology transfer is essential to enhance technology development.

As indicated by Cao, Zhao and Chen (2009: 3), Ramanathan (2008: 4) and Teng (2010: 297), technology transfer encompasses the following:

- Technology transfer may be mutually agreed upon, intentionally goal-oriented and a proactive process by which technology flows from the entity that owns the technology (transferor) to an entity seeking the technology (transferee). The transfer involves cost and expenditure that are negotiated and agreed upon by both parties. The transfer may be said to be successful if the transferee can successfully utilize the technology for business gains and produce an end product for public good.

- The technology transfer model depends mainly upon the strategies of the transferor and transferee and the technological capability of the transferee. The transfer may be successful if the transferee can successfully utilize the technology for business gains and eventually assimilate it.

- It is a process of converting scientific findings into useful products or services for society.

Snu (2012: 11) stated that technology transfer can also be described as market pull or technology push. It occurs as a result of market pull when a need or problem causes companies to seek solutions. Technology push occurs when an innovation is used to create new markets or to satisfy consumer needs. The overall objective is to get federally developed research and development (R&D) out into the marketplace for commercialization. The opportunity exists, however, for government to bring technology developed by industry into the R&D arena for further research, development and commercialization. This would be to the benefit of all potential partners.

1.2.2.2 Commercialization

Commercialization is the process of turning an idea or innovation into a useful product or service. Tanha (2011: 23) affirmed that commercialization is turning an idea or innovation into a marketable product or service that will yield a profit. Commercialization is a component of the broader innovation process which includes trials or studies that make a financially viable operation more profitable.

Commercialization is at the intersection of innovation and entrepreneurship, which according to Prebble, de Waal and de Groot (2008: 312) comprises of activities that bridge the gap between economic value creation and economic value realization. Commercialization is a process of transforming new technologies into commercially successful products. Thus, the process as explained by Reamer *et al.* (2003: 21) includes interventions such as market assessment; product design; manufacturing; management of intellectual property rights; marketing strategy development; raising capital; and worker training. In general, commercialization describes the process of transforming research into practical application with commercial potential, obtaining patent protections rights for innovations and then transferring them to industry via licence agreements or new start-up companies.

Commercialization is a series of activities undertaken to transform knowledge and technology into new products, processes or services, in response to market opportunities. Therefore highly skilled workers such as researchers, engineers and managers are critical to the commercialization process, as is a culture that values innovation and entrepreneurship (Earl and Gault 2008: 11). Corkery (2011: 4) further defined commercialization as an operation that is dedicated to an activity that has been proven to be viable. This implies that the elements or assumptions of the activity have been proven and can be modelled in a business plan. The objectives and expectations are to create a profit.

Commercialization, also known as research commercialization, is the valorization of research and intellectual assets by industry, or the process of taking an idea to market, thereby creating financial value. It can imply either the selling, licensing of or contracting

of technology services, intellectual assets and related knowledge into spinoff creation and R&D collaboration (Zuniga and Correa 2013: 3).

1.2.3 Intellectual Property

Intellectual property is the product of the human intellect which is new, unique and innovative, and that has value in the marketplace. Intellectual property is generally characterized as non-physical property that is the product of original thought and its rights surround the control of physical manifestations or expressions of ideas (Stanford Encyclopaedia of Philosophy 2014: 1). Kieff (2006: 1) expressed that intellectual property law transforms useful knowledge from an inherently non-excludable good into an excludable good that can be bought, sold and licensed within an economic system. North (2010: 1) confirmed that rights afforded to intellectual property have been created to increase the rate of return on investment in the production of new knowledge. Kieff (2006: 1) further stated that intellectual property law, and patent law in particular, provide the raw material for the technology transfer system. Intellectual property legal titles relate to the acquisition and use of a range of rights covering different types of creations. Innovations may be protected under one of the many types of IP, namely: copyright, design right, domain right, patent, trade mark and trade secrets.

1.2.3.1 Trade Secret

A trade secret is a facet of IP; the information is a secret or is not known in the relevant industry, which affords the owner an advantage over competitors. Trade secret protection exists as long as the information has value, is kept a secret by the owner, and is not lawfully obtainable by others. Trade secrets include product formulas, patterns, methods, techniques, manufacturing processes and compilations of information that provide the

business with a competitive advantage, for example Coco-Cola. Quinn (2009: 2) confirmed that a trade secret is any valuable business information that is not known and is subject to reasonable efforts to preserve confidentiality. A trade secret is protected from misappropriation and exploitation by those who obtain access through improper means, or who breach a promise to keep the information confidential (Hammersla 2006: 3).

1.2.3.2 Copyright

Copyright protects the physical expression of ideas. Once an idea is given a physical form it is afforded copyright protection. Examples may be in the form of a piece of writing, photograph, music, film or a web page. There is no formal registration process for copyright. Protection is automatic at the point of creation (Bobbitt 2006: 11; Loggie *et al.* 2007: 226; Zhang and Carr-Chellman 2006: 179). Both published and unpublished works are protected by copyright. Copyright law provides ownership of the work to the creator. Once the work is created then entitlement is automatic, and it is copyright law that assures and provides protection to the original creator. Gupta (2012: 15) confirmed that the copyright law grants several rights, which include the right:

- to reproduce the work;
- to prepare derivative works;
- to distribute copies;
- to perform the work; and
- to display the work publicly.

1.2.3.3 Patent

As Quinn (2009: 6) reported, a patent is a proprietary right granted by a patent office to a creator of an innovation. There are three very different kinds of patents, namely: i) a utility patent, which covers the functional aspects of products and processes; ii) a design patent, which covers the ornamental design of useful objects; and iii) a plant patent, which covers a new variety of a living plant. A further explanation by Gupta (2012: 11) is that a patent is a concise and elaborate means of protection for innovations of new and improved products and processes that are capable of industrial application. A patent is a form of intellectual property that is novel, non-obvious, and useful. The inventor is given the exclusive right to prevent others from making, using and selling a patented innovation for a fixed period of time, in return for the inventor disclosing the details of the innovation to the public. Patents are granted by national offices, such as the US Patent and Trademark Office (USPTO) and the Companies and Intellectual Property Commission (CIPC) in South Africa. When a patent is granted the innovation becomes the property of the inventor, which can then be bought, sold, rented or hired (McMaul 2009: 6).

It is generally accepted that intellectual property in the form of the number of patents granted to its nationals can be used as a proxy for the extent of innovation, and the current and future economic growth potential in a country (Sibanda 2008: 30). It is also found that among the different types of intellectual property protection measures, patents are globally accepted as a reflection of a country’s inventive and technological achievements. Patents are used for monitoring and assessing national systems of innovation.

1.3 Context of the research

Creation, protection and the commercialization of new innovations are crucial to sustain a competitive edge. Universities need to promote innovations for industry to create new and higher value markets for countries to retain a competitive edge in the current global economy. The crucial benefit of an innovation within a country's patent system is recognized as a mechanism to develop a competitive advantage. The process for transferring research results from university laboratories to commercial applications are complex and varied. The need to better understand technology transfer and commercialization practice is accelerated by increasing expectations of universities to act as agents of economic development. Technology-based venture companies are important for growing economies, especially from new university innovation spin-offs. Further, the growth and well-being of developing countries such as South Africa depends on the ability to commercialize innovations for local and international markets and to expand trade horizons. More importantly, the need for universities themselves to function more efficiently and effectively is critical to the benefit of research.

Baxter (2011: 6) stated that universities are not focused exclusively on maximizing business advantage or profits; the concern is with maintaining scientific excellence, together with realizing the institution's mission and goals. For example, industry may view the cost of patent protection as a necessary expense since registered patents are considered a business asset. On the other hand, universities may view the same cost as non-essential to their core mission. Further, according to Tornatzky and Fleischer 1990, cited by Lin (2009: 6), when universities seek patent protection they are more inclined to apply for protection early in the innovation process, with a broad set of specification claims. Industry, on the other hand, are consistent with more focused business objectives and might be more inclined to seek narrower protection and to delay the filing of a patent until an innovation is well- developed in their laboratories. This variance in culture and behaviour has created problems and tensions for university technology managers, as this results in delayed publication and conference presentation.

The manner in which innovations are exploited is influenced by three main factors. These are the innovators and university management, their characteristics and motivation for decisions taken; the characteristics and nature of new innovation technology; and the lack of university intellectual property and technology transfer office (IP&TTO) experience, resource and due diligence system.

The reasons why some university innovations are exploited through spin-off formations or by licensing to establish companies, and others are not, formed part of the research study. This study investigated the reasons why a high percentage of university patents remain unutilized with no return on investment to the university or the government. Moore (2009: 2) stated that the over-arching principle at play is that where State funds are utilized to generate intellectual property, the State and the public should receive some benefit from that IP. This study investigated the management of the innovation landscape of universities in South Africa through a survey distributed to the 23 university IP&TTO managers. An interview schedule was also utilized for data collection from researchers in possession of innovation with the potential of commercialization. The views and comments of innovators of exploited and unexploited innovations were collated, analyzed and presented through a summary in Chapter 7. While each university has policies for innovation initiated from publicly financed research, it is important to investigate the methods employed and to understand the issues associated with the commercialization of university innovation. Additionally, this study provides insight into the number of registered patents, the management thereof, and factors contributing to the commercialization of innovation.

1.4 Research problem and aims

This study investigated the problem of a high percentage of university patents that are registered, but remain unutilized with no return on investment to the university or the government. Ismail, Majid and Omar (2011: 80) reported that universities continue to register patents, even though the ratio of commercialized patents remains small compared with unexploited patents. It is often found that IP developed by inventors lies idle at universities or is sold off to private companies, often abroad, with no benefit accruing to the university, the government or the people of the country. This type of situation is affirmed by Moore (2009: 2), in stating that the over-arching principle at play is that where State funds are utilized to generate IP the State and the public should receive some benefit from that IP.

A decade ago, a science and technology syndrome struck Europe (Van der Wende 2009: 319). Are South African universities suffering from the same science and technology syndrome that had struck Europe, known as the 'European Paradox'? The paradox could be formulated on the basis of the following questions:

- Why is the South African economy not benefitting from public investments in research and development from university innovations?

- Are personnel suitably qualified and is the science and technology educational infrastructure strong?

The focus of this study is a proposed framework to explore answers to, or reasons for, the unanswered questions.

Innovation has several significant benefits. Reduced government subsidies forced South African universities to generate third-stream income to supplement depleting budgets. Funding constraints could be minimized by increased commercialization of university innovation. Further, innovation performance is also a crucial determinant of competitiveness and national progress. More importantly, innovation addresses global challenges. The OECD (2013: 1) stated that despite the importance of innovation many countries face difficulties in strengthening performance in the field of innovation commercialization activity.

It must be noted, however, that neither the conversion of ideas into products nor a product encounter with the marketplace is always successful. One needs to enquire as to what the factors and processes are that favour success in this area. Many analysts believe that the key to this question lies in studying the process by which innovative products are commercialized (Teece 2010: 1). The growth and well-being of South Africa’s population depends on the ability to commercialize innovations in the local market and to expand trade horizons in the international market. Puri (2009: 17) argued at the Bio2Biz SA 2011 conference that there was a need to protect IP developed in South Africa from being sold to foreign companies. Bansi (2012: 14) added that such IP was often brought back in the form of a commercial good, at a premium price to the people of the country. Undoubtedly, the capability to innovate and to successfully bring innovation into markets is the crucial determinant of the global competitiveness of a nation. The OECD (2011: 2) emphasized that innovative activity is an important driver for economic progress and a potential factor in contributing to global challenges.

Universities can benefit from the commercialization of research by transforming knowledge and technology into commercially useable forms (Harman and Harman 2004: 154). It is therefore the responsibility of the university intellectual property and technology transfer offices (IP&TTO) to ensure that research generates revenue by being actively involved in activities that bring innovation to the market. The accelerating pace of innovation is being driven by globalization, in addition to the rapid advances in scientific discovery and general-purpose technologies. According to Davood (2011: 10) one of the most important attributes of an innovation is its potential to be commercialized.

The apparent lack of the commercialization of university innovation forms the basis of this research study. As Peng (2006: 923) posited, a gap exists between university research results and the commercialization of innovation. The consequences of the realized gap of university innovation not being commercialized results in the loss of government investment in research and development. The return on investment is important for the economic success and global competitiveness of the nation. This study therefore aims to analyze the nature, extent, causes and consequences of the gap between university innovations and the commercialization thereof. The study focused on developing an understanding of the process of innovation at universities being successfully transferred to industry for commercialization. Additionally, the study examined efforts undertaken by universities to convert innovation into tangible outcomes, and the subsequent challenges associated with the process.

1.5 Objectives of study

The motivation for this study was attributed to the substantial success that American universities have had over the past three decades in commercializing patented innovations. This success was largely due to the enactment of the Bayh-Dole Act of 1980. The primary effect of the Bayh-Dole Act was to implement a change in ownership title of innovations resulting from federally funded research. The Bayh-Dole permits the university to elect to pursue ownership of an invention in preference to the government. The researcher focused on investigating the contributing factors to the low rate of commercialization of innovation at South African universities. This was done by focusing on the research objectives outlined below:

- ❑ To investigate the present relationship between research and the commercialization of innovation at universities in South Africa.
- ❑ To determine the ways in which innovation can be commercialized.
- ❑ To determine the cause of the apparent gap between research and commercialization.
- ❑ To propose effective ways for increasing the extent of commercialization to the potential benefit of the country.

1.6 Significance of the study

The effective development and exploitation of IP resulting from publicly funded research at universities has the potential to provide significant benefit to a nation's economy. The quest for a global competitive advantage and increased standards of living has progressed the government's investment in research and early-stage product development to enhance investment readiness (Wessner 2012: 27). This has increased entrepreneurial activity and spurred economic growth (Shane 2012: 1). This increase in activity has largely been due to university/industry collaboration. Attention to translating basic research and technology advances into commercial products is of the utmost importance. Once a university has developed knowledge in the form of a product or process, the focus on entrepreneurial activity and strategic positioning is of crucial importance in generating economic benefit.

Technology transfer and the commercialization of innovation is the process through which the outputs of academic research are conveyed to industry in order to effectively utilize research results; this can be done directly or indirectly. The direct method of commercialization can occur in various ways through industry collaboration, contract research and the formation of a new company through licensing to exploit new technologies (Cohen and Walsh 2007: 4). The indirect method of transfer is achieved through education and research-based teaching, publication and reports, as well as workshops, seminars and conference presentations (Geuna and Muscio 2009: 94).

The significance of commercialization activity at universities directly impacts on enhancing the standard of living; quality of life; economic growth of the country; increased competitive advantages; productivity; and market success. In light of the aforementioned benefits of the commercialization of university research, this study served two purposes:

- to encourage an increase in commercialization activity at universities to improve the return on investment; and

- to highlight the characteristics of IP&TTO's at universities that facilitate and lead to improved performance on commercialization activity.

As presented in literature, the internal factors within universities and the IP&TTO's have the potential to influence the development of innovation. Success of the IP&TTO at universities is largely determined by the manner in which IP is managed. Universities with more resources will be more successful in achieving their goals (Gras *et al.* 2008: 188). Individual characteristics of university researchers, university management and IP&TTO staff have a direct effect on commercialization activity. O'Shea *et al.* (2008: 654) suggested that the investment in recruiting and retaining top ranked intellectual property and technology transfer office staff is of critical importance. Gras *et al.* (2008: 197) found that universities with leading, prominent researchers are more likely to commercialize their innovations. This enhances the entrepreneurial credibility of the university, which is important to potential investors who use the prestige and entrepreneurial credibility of a university as a benchmark to invest.

Another major significance of this study is highlighted by Buenstorf (2009: 281), who supports the stance that the commercialization of innovations provides a potential source of income for universities, thereby reducing dependency on government or public funds. The expected benefits from the results of this study are as follows:

- The most important benefit of this study is to identify characteristics to increase and enhance the commercialization of innovation at universities. This will be achieved from innovators interviews with innovation of commercial potential, responses from IP&TTO questionnaires and the review of literature.

- The development of an innovation valuation survey to assist IP&TTO staff.

- The results of this research could be utilized as a guideline to yield better use of intellectual property assets. Although university environments may differ, best practice and guidelines derived from these research results can be extended to improve efforts in bridging the gap between academic research and commercial application that is applicable to all universities.

- This research aims at deriving a commercialization model.

- Government may benefit from understanding the factors experienced by universities in commercialization activity.

- The study will assist by increasing the commercialization of innovations and will highlight characteristics that lead to improved performance and commercialization activity by growing an entrepreneurial culture at universities.

While investment by government and private funders in research and development are a crucial source of knowledge, so too are investments made in research and innovation at universities. Interestingly, and as stated by Senator Birch Bayh and quoted by Litan, Mitchell and Reedy (2007: 32) "investments in university research do not automatically spill over to generate innovative activity and economic growth". Large amounts of valuable research and a wealth of scientific talent is going to waste as a result of the possible lack of an entrepreneurial culture at universities. Moore (2009: 1) postulated, therefore, that in terms of the South African IPR Act the legislation seeks to address the situation where intellectual property lies idle at universities or is sold off to private companies, often overseas, with no benefit accruing to the university, the government or the South African people. It therefore necessitates universities to actively facilitate the spillover of research. Litan, Mitchell and Reedy (2007: 34) emphasized that a perennial challenge related to university-driven innovation is to ensure that structures at universities assist, not hinder, the innovation commercialization process.

The value of this research study provides an insight into the unique challenges faced by university researchers. The results will also provide diverse perspectives on the commercialization of university research, as employees, researchers and IP&TTO managers were included in the analysis.

1.7 Literature review

There is a sizeable body of literature on the topic of the commercialization of university innovations available from an international perspective. Most studies have focused on the American context, although more recently the issue is receiving increased attention in European countries (Nosella and Grimaldi 2009: 679; Gulbranson and Audretsch 2008: 251). Literature on the commercialization of university innovation in the South African context, however, is very limited.

An increased interest in the facilitation of technology transfer and the commercialization of innovation has been globally noted in recent years. The management of intellectual property assets and its processes has been adopted not only by inventors and universities, but also by politicians, managers and industry consultants. The need for new technology has grown tremendously due to increased global competition and rapid structural changes in the markets. Various mechanisms are utilized, such as patent registration and out-licensing, with spin-off companies playing an equally important role in this arena. The increasing number of registered patented innovations is an excellent indicator for the acceleration of the innovation process and the need for higher output (Eurostat Regional Yearbook 2011: 3). The rate at which university innovation is being commercialized in South Africa, however, is not sufficient to keep up with global trends.

The approach to the technology transfer and commercialization process is unique to institutions and is often based on the institutional mission, long-term goals and values. The main responsibility of the IP&TTO is to ensure that the commercialization of innovation generates revenue for the university, thereby exposing new innovations to industry and the marketplace. The IP&TTO's role is pivotal in providing an interface between the university and industry partners. As established, the main objective of an IP&TTO is that activity must lead to the profitable commercialization of patents and ideas (Carlsson and Fridh 2002: 200). For IP&TTO's to achieve results they have to implement processes that bridge organizational objectives between two parties, namely, the university and industry (Zhao and Reisman 1992: 15). Innovation provides the link for university/industry collaboration; thus, this collaboration provides the vehicle for the diffusion of innovation. Appropriately managing innovation is integral in transferring innovative ideas to products and performance. Wessner (2012: 1) further explained that income is generated as a result of the process by which an idea or innovation is translated into goods or services for which people will pay. To be recognized as an innovation, the idea must be replicable at an economical cost and must satisfy a specific need.

Globally, IP&TTO's generally monitor ongoing research by engaging in collaboration with all faculty researchers. They collaborate with appropriate commercial partners to fund ongoing research. On disclosure of an innovation, the IP&TTO evaluates the strength of the opportunity from a commercial perspective (Young 2012: 3). Should the innovation display the potential for commercialization, the IP&TTO will proceed with the application to secure intellectual property rights. On obtaining these rights the IP&TTO will pursue potential commercial partners for a license agreement or other form of alliance (Sun and Baez 2009: 11). Financial benefit emerging from the successful commercialization of innovation that constitutes a return is generally guided by the terms of the university's intellectual property and distribution policy. The goal of most IP&TTO's is to ultimately become financially self-sustaining. Other benefits and metrics in addition to revenue generation include: societal benefit of the technology; enhancement of the institutions reputation by the success of researchers; and success of the technology transfer office as a service for faculty (as measured by the rate of growth in innovation disclosures).

Institutions undertaking research cannot only cover themselves by the number of new innovation disclosures, but have to measure up to the economic feasibility of their innovations. In a study conducted by Kornfield (2011: 2), it was found that the problems in commercialization were characterized by incentive structures and income distribution between the innovator and industry. It is therefore important to investigate the kind of incentive structures universities and industry should employ in order to facilitate the optimal transfer of knowledge. Commercialization is therefore seen in the context of this research, as a planned and time-limited process of transferring technological know-how with an agreement between two institutions to enhance the competitive ability of an institution and the inventor alike. To improve the commercialization of innovation, universities ought to focus their attention on alleviating barriers to the process of technology diffusion. Turning an idea into an innovation, and subsequently into a commercial product or service, is very complex and requires concerted effort.

Rasmussen and Rice (2012: 1) described three mechanisms in promoting the commercializing of university research. Firstly, by extending academic research to be further developed for use. Secondly, by extending the role of commercial actors and investors who are ‘receivers’ of technologies, developed on the basis of academic research. Thirdly, by supporting the development and engagement of inter-mediators. Rasmussen and Rice (2012: 1) further advised that the above three mechanisms are not mutually exclusive, and when implemented together they can result in synergies that improve efforts to bridge the gap between academic research and commercial application. The mechanisms are complementary and the activities related to development, if implemented together to fit the local context, can prove beneficial. The first mechanism can be achieved by increased activity to develop and to advance technology beyond the expected end point, which will assist in taking the product closer to bridging the gap from research to commercial application. Secondly, incentives are needed for commercial partners to engage sooner than they might otherwise be willing to get involved in the innovation. Incentivizing industry partners could increase efforts for rapid development. This is supported by Borlaug *et al.* (2009: 160), who stated that research and development contracts and tax deduction schemes are actively used to develop university technology. The third mechanism by supporting the development and engagement of all involved partners extends the technology push and pull, thereby creating an opportunity to gain leverage. Through combined actions by government entities, industry partners and by extending the traditional role of the university, the gap between university innovation and commercial application may be reduced.

The importance of understanding how university innovations have become integral in this era of volatile change is critical. Innovations emanating from universities are considered as significant factors in the economic stability of countries. More recently, new IP legislation has emerged dictating commercialization that drives the innovation process. It is therefore necessary to understand these trends and imperatives to accelerate the pace of innovation becoming available for public benefit. The increased push to improve the efficiency and effectiveness of processes is due to factors such as globalization and outsourcing. Challenges associated with the process have become an integral part of daily occurrences in South Africa's effort in becoming a significant partner in global trade for employment growth and poverty reduction. Through research and development universities are a major source of innovation for which they can be correctly positioned as innovation drivers.

1.7.1 Benefits of technology transfer and commercialization

Globally the commercialization of innovation has taken on great significance, thereby placing universities in a position of leadership within the realm of technology-based economic development. Similarly, Litan *et al.* (2007: 1) stated that as technologies have grown to be more sophisticated emerging industries have become high-tech and more advanced; universities too have become more important players in new innovation. Bradley *et al*. (2013: 1) concurred that university-discovered technologies play a major role in bringing innovative ideas to the market that drives economic growth. Commercialization activities, which a few decades ago were only practiced by elite universities such as Stanford, Harvard, Oxford and Yale, are now a phenomenon practiced worldwide. Technology transfer can potentially generate revenue for universities; create research connections between academia and industry; and enhance regional economic growth and development, as evidenced by the aforementioned universities (Bradley *et al*. 2013: 1).

Litan, Mitchell and Reedy (2007: 1) declared that today we take for granted the rapid pace of progress that has carried many national economies forward over the past 200 years. The continued diffusion of innovation into the marketplace has made progress possible. The process of transferring innovation from university to industry was not a role undertaken by most university researchers. Instead, university researchers were content to concentrate on teaching and basic research. The benefit of improving the human condition by the transfer and commercialization of discoveries serves the interests of not only the inventor, but also of society (Litan, Mitchell and Reedy 2007: 7). This is highlighted by the National Academy of Science and Engineering (2006: 11) which argued that "since the Industrial Revolution, the growth of economies around the world has been driven largely by the pursuit of scientific understanding, the application of engineering solutions and continual technological innovation". Ideally, in supporting aspects of this process from research to innovation, as well as commercialization, university structures can drive national economies forward.

1.7.2 Focus of technology transfer and commercialization

The main focus of universities IP&TTO's towards the commercialization of research is for the dissemination of research results for the public good and economic development. The degree of success depends not only on the nature of the interface between the university and business, but also on the receptivity in the surrounding community. It also depends on the culture, organization and incentives within the universities themselves (Carlsson and Fridh 2002: 199). Literature reveals that high numbers of patents are not brought to the market, and therefore remain unutilized. Giuri (2007: 1108) confirmed that from a survey assessment of 9 017 European patents, results revealed that 36% of patents are not used; 50% of them are blocking patents; with the remainder being unutilized. This propelled the Leahy-Smith America Invents Act (AIA) which reformed the USA patent system which made major contribution by recognizing the importance of speeding up the patent process, so that innovators and entrepreneurs can turn a new innovation into a business venture as quickly as possible (Gupta and Feerst 2012: 1).

Mowery, Sampat and Ziedonis (2004: 6) argued that the increased focus on commercialization has changed the research culture of USA universities, leading to increased secrecy, less sharing of results, and a shift in the focus of academic research away from fundamental towards applied research. The Bayh-Dole Act created incentives for universities to move away from basic research which produced less patents and towards applied research to gain more royalties from patenting. This is supported by Baxter (2011: 34), who asserted that university research is skewed towards marketable products and not basic research. Evidence suggests that universities are accelerating commercial activities with the focus on income generation, thus resulting in a shift away from basic research.

Pradhan (2009: 2) stated that "since 1980, American universities have spun off more than

5,000 companies which have been responsible for over 260,000 jobs. This result has been a contribution of over $40 billion dollars annually to the American economy". Pradhan (2009: 3) further stated that university innovations were the sole contributors of these economic benefits. Job creation and revenue contribution to a nation's economy were the positive effects resulting from increased commercial activity.

In an attempt to advance patent registration in South Africa, the Government created a public funding agency, the Technology Innovation Agency (TIA), to bridge the innovation gap between the local knowledge base and the productive economy (Bansi 2012: 66). The objective of the TIA is to stimulate the development of technology-based products, services and enterprises for the South African economy. This has facilitated the development of human capital for innovation and has provided a primary bridge between the formal knowledge base and the real economy. There is a trend whereby research institutions have become focused on the commercial value of their registered patents in a national context (Bansi 2012: 114). This has typically led to increased activity in the area of formalizing universities' IPR policies, the formation of IP&TTO's, and an attempt to either license IP to commercial entities or to create spin-out companies based at universities (Hindle and Yencken 2004: 796).

The Director-General of Science and Technology, Mjwara (2008: 1), highlighted that South Africa had not been "100% up to speed" in the way it managed intellectual property rights. He stated that, "what we find in South Africa is that research gets exploited overseas, in terms of converting the research results into technology development and production, and then we have the transfer back from overseas into local industry" (Mjwara 2008: 1). This situation should be rectified with the proper measures in place. Transferring back into the country at a premium price is hardly the most feasible method to benefit South Africa and its citizens. Moore (2009: 1) concurred, and further postulated that "the Act seeks to address the situation where intellectual property developed by researchers, lies idle at universities, or is sold off to private companies, often overseas with no benefit accruing to the university, the government or the South African people".

To alleviate further occurrences in South Africa, as mentioned earlier, the Government has implemented measures to correct the situation of new innovation being lost to overseas companies. To rectify the current loss of IP, preference should be given to transfer protected innovation locally to increase and extend the annual turnover of South African industry partners.

1.7.3 Entrepreneurship and commercialization

The success of any commercialization process depends largely on the entrepreneurial skill of the IP&TTO and the innovator collectively. Stanford University is known to have a long history in technological innovation entrepreneurship. Eesley and Miller (2012: 6) reported that for more than a century Stanford University has incubated ideas, educated entrepreneurs and fostered breakthrough technology that has been instrumental in the rise and constant regeneration of Silicon Valley, which contributes to the broader global economy. Graduates from Stanford University have been responsible for building numerous businesses which are amongst the top most leading and well recognized companies of the world, such as Google, Yahoo!, Nike, Cisco, Hewlett-Packard, Gap, VMware and IDEO. Farnham (2012: 4) reported that an estimated 39 900 companies can be traced with roots to Stanford University. Eesley and Miller (2012: 6) further stated that those companies have created an estimated number of 5.4 million jobs and generate $2.7 trillion in annual revenue. The question one asks, therefore, is: How does Stanford University create this innovative entrepreneurial ecosystem? According to Eesley and Miller (2012: 7), students in all faculties at Stanford University receive their education in the context of a robust liberal arts environment that provides them with a broad world view that is required for them to be the innovators and leaders of tomorrow. Stanford University encourages networking and collaboration across all disciplines and offers facilities for the testing of ideas. It also encourages students involved in research to actively prototype their ideas. Stanford University's approach to innovation entrepreneurship is to bring together cutting-edge technology and real-world expertise (Eesley and Miller 2012: 3). According to a survey conducted by Stanford University (2011: 5), technical innovators who created new products, production processes or business models were alumni who had participated in entrepreneurship courses and programmes offered at the university. The process through which new innovation is transferred from universities to the marketplace requires high levels of entrepreneurial skills to ensure that the desired results are achieved for economic growth and competitiveness. The Innovation Policy Platform (IPP) (2014: 1) stated that the pace and effectiveness of knowledge transfer impacts on the contribution to economic development. The IPP called for awareness regarding the processes and the key individuals involved; the conditions that enable such processes; the factors that affect the demand; and the rationale and means for policy intervention.

1.8 Research methodology

This section describes the methodology utilized for this study.

1.8.1 Research design

There are three approaches to research: qualitative, quantitative, and mixed methods. The distinction between the qualitative paradigm and the quantitative paradigm lies in the quest for understanding an in-depth inquiry (Coombes 2004: 30). This statement is supported by Babbie and Mouton (2010: 123), who explained that with qualitative research the primary aim is an in-depth description and to obtain a better understanding of actions and events that are undertaken by an organization. Quantitative research is a formal, objective, systematic process in which numerical data is used to obtain information to describe variables; to examine relationships among variables; and to determine cause-and-effect interactions between variables (Burns and Grove 2005: 23).

Creswell and Garrett (2008: 8) referred to mixed research methods as a means of collecting, analyzing and using both qualitative and quantitative data within an established approach. The advantage of using mixed methods for research is the ease with which findings are reconciled (Hammond 2005: 16).

This study utilized both qualitative and quantitative research paradigms. The mixed methodology was chosen to investigate how universities can better encourage the commercialization of university research. The research instruments included surveys in the form of a questionnaire and a semi-structured interview schedule. The sampling technique utilised was purposive sampling based on respondents with the knowledge, background and experience to complete the survey. Convenience sampling was utilized for the interviews.

1.8.2 Population

Welman, Kruger and Mitchell (2005: 52) explained that the population can consist of individuals, groups and organizations. The population for this study included IP&TTO managers and innovators. For this study the target population included the 23 university IP&TTO managers in South Africa. The source list (Appendix A) was obtained from the Department of Higher Education, which indicated a total number of 23 universities at the time that the research study commenced in 2013. The target population also consisted of thirteen university innovators in possession of registered intellectual property with the potential of commercial application.

1.8.3 Sampling design

Maree (2003: 36) stated that probability and non-probability sampling are the two sampling techniques used in research. The difference between *probability* and *non-probability sampling* has to do with a basic assumption on the nature of the population under study. In probability sampling, every item has a chance of being selected. In non-probability sampling, there is an assumption that there is an even distribution of characteristics within the population. Maree (2003: 39) further attested that convenience sampling, judgemental sampling, quota sampling and snowball sampling are non-probability sampling techniques. The questionnaire was sent to all 23 university IP&TTO managers in South Africa, which denotes the census sampling method. From the 23 questionnaires that were dispatched a total of 21 completed questionnaires were received, which indicates a 91.3% response rate. Convenience sampling is a sampling technique in which participants are selected because they are easy to access (Teddlie and Yu 2007: 81). Convenience sampling was used to interview innovators at an innovation exhibition arranged by the Department of Science and Technology in an effort to promote innovation. A total of thirteen innovators were interviewed.

1.8.4 Primary data

Primary data is information collected by a researcher specifically for a research assignment. McNeill and Chapman (2005: 131) defined primary data as being collected first-hand mainly through the use of research methods such as surveys utilizing a questionnaire, interviews and participant observation. For this study the primary source of data collection consisted of a structured questionnaire and a semi-structured interview schedule.

1.8.4.1 Questionnaire

A questionnaire was one of the two instruments utilized for data collection in respect of this research study. Maree (2003: 108) specified that the characteristics of any standardized measuring instrument are that it must be valid, objective, suitable and feasible. The questionnaire was comprised of eight sections which were made up of: a) Biographical data; b) Awareness of IP legislation and IP policy; c) University commercialization environment; d) Management of commercialization activities; e) Status of registered patents; f) Early stage financing and venture capital; g) Industrial linkages; and h) General views. The questionnaire made up the main data collection instrument in the study.

An electronic communication method (Appendix B) requesting consent to participate was forwarded to all 23 universities, either to the Deputy Vice-Chancellor (DVC) or the Research Director. Upon consent being granted, the prepared questionnaire was sent to the IP&TTO managers via the electronic medium.

1.8.4.2 Semi-structured interview

Interviews are regarded as a suitable method to collect information; they are typically conducted between an interviewer and an interviewee or respondent. A semi-structured interview schedule was utilized to collect the data because it allowed for flexibility. The responses were captured on the interview schedules. This technique was found to be the recommended and most suitable method to gather data for the interview session and the study at hand.

The schedule was designed around themes which initially defined the research topic but allowed for divergence where relevant and appropriate (Whiting 2008: 37). This design enabled questions to emerge from the dialogue with no obligation to pursue the pre-planned questions if they were not relevant to that participant (Whiting 2008: 37). The flexible nature of the semi-structured interview was important for the investigation of the research question, as it allowed for unexpected topics to be raised. Some of the topics that were raised included the limited entrepreneurial knowledge and skills amongst researchers, and the difficulties of the university in attracting and retaining experienced IP&TTO staff to assist innovators with commercialization activity.

Innovators were personally interviewed at an innovation exhibition arranged by the Department of Science and Technology to promote university innovations during January 2015. Questions were presented to the innovators to gain information regarding the status of innovation; funding opportunities; attempts made to commercialize; and the manner in which innovations were managed at their respective universities.

1.8.5 Secondary data

According to Cohen, Manion and Morrision (2007: 161) secondary sources are those that do not bear a direct physical relationship to the event being studied; it is made up of data that cannot be described as original. Secondary data for this study was sourced from a comprehensive review of internet database articles, journal articles, relevant books, research studies and legislation.

1.8.6 Data analysis

Davies (2012: 205) proffered that the analysis of data utilizing the multi-method or triangular method allows one to keep the findings separate, thereby enabling the researcher to build a cumulative portrait of the subject. The software programme SPSS was utilized to assist in the analysis of the quantitative data. Descriptive statistics including summarized data using tables, graphs and calculating descriptive measures of responses received from questionnaires, were analyzed.

All interview responses were recorded on the schedule and analyzed using the method of thematic analysis in order to identify, analyze and report patterns within the data (Braun and Clarke 2006: 97). Probability theory was used to quantify uncertainties about the conclusions that were generalized (Maree 2003: 90). Common themes from the questionnaire and interview responses were identified. Thereafter, a comparative analysis was undertaken between the results obtained from the questionnaires, the interview schedules and the literature review. This method of analysis has the advantage of being flexible as it can be applied across a range of theoretical approaches and paradigms. It can also provide a rich and detailed account of the data (Braun and Clarke 2006: 97). This approach allows for themes to be derived across a large number of cases and diverse data set (transcripts). The quantitative aspects from the questionnaire and interview responses were coded, analyzed and represented by means of graphs.

1.8.7 Validity and reliability

Literature identifies two principle categories of challenge to research credibility:

- ❑ Validity, or "… the extent to which the data collected truly reflect the phenomenon being studied" (Ticehurst and Veal 2000: 23).
- ❑ Reliability, or "… the extent to which research findings would be the same if the research were to be repeated at a later date, or with a different sample of subjects" (Ticehurst and Veal 2000: 24).

Validity applies to research methods involving positivistic elements, therefore both survey instruments were designed to collect the data (Yin 2009: 17). As posited by Saunders *et al.* (2003: 11), reliability is the degree to which data collection method(s) yield consistent findings, and similar observations would be made or conclusions reached by other researchers from the raw data. The questionnaire was designed and pre-tested to ensure that the questions were clear in order to yield results relevant to the research objectives. Care was taken to ensure that the instructions for the completion of the questionnaire were clear and unambiguous. The vocabulary utilized reflected terminology familiar to the university IP&TTO environment, which was also found in related literature. The validity of the study was derived from the composition of the respondent group, the type of questions employed and the wording.

The main focus was on whether members of the respondent group had adequate knowledge to be able to respond to the questions. Considering that the questions were answered by IP&TTO managers who were appointed on consideration of qualifications and experience, it was considered reasonable to assume that they had the requisite knowledge to offer an informed view. It was also assessed as reasonable to expect that respondents would understand the questions. This ensured that responses from participating HEI's were consistent. Reliability was established through pre-testing the research instruments, i.e. the questionnaire and the interview schedule were piloted with ten innovators (who were not included in the main sample) at the Durban University of Technology to test clarity and the interpretation of questions in order to ensure consistency. On concluding the pre-tests, amendments were made to correct the language which ensured the correct interpretation of questions.

1.8.8 Anonymity and confidentiality

The anonymity and confidentiality of participants are central to ethical research practice. The researcher assured participants that the data provided would not be traced back to them in reports, presentations or other forms of dissemination, thereby respecting their preference to remain anonymous. Anonymity of information collected from respondents meant that the research instrument did not collect identifying information of individual subjects such as names, addresses and e-mail addresses. By maintaining the confidentiality of information collected from research participants, the researcher made every effort to prevent anyone outside of the research project from connecting individual subjects with their responses. The data was only accessible to the researcher and the research supervisors. The data will be destroyed after a period of five-years.

1.8.9 Ethical considerations

Silverman (2010: 155) declared that “research participants must participate in a voluntary way, free from coercion. Consent has to be freely given for the research to be valid”. This condition was guaranteed as part of the process of securing ethical clearance. The first contact with each HEI was to obtain consent for participation in the study. The communication included a covering letter outlining the proposed study. Requests for participation were made through each university’s DVC office or Research Director. On approval by the relevant university management, each IP&TTO was sent the covering letter and a consent form that was approved by the Durban University of Technology Research Director. Throughout the study the researcher ensured that the participant’s integrity was respected. The research complied with the ethical requirements of the Durban University of Technology.

1.8.10 Structure of dissertation

This study will be reported in eight chapters; a brief description of each chapter is provided below.

Chapter 1 – Introduction

The introduction laid the foundation and set the orientation of the research study. The context of the research was discussed, including key concepts, the research problem, the aims and objectives. The significance of the study as well as the expected benefits were highlighted. An overview of the study is the focus of Chapter 1.

Chapter 2 - Public management and higher education

The theoretical framework of the study is highlighted. A review of public management, new public management, higher education institutions and legislation related to intellectual property are discussed. Challenges relating to intellectual property within higher education and entrepreneurship are also presented.

Chapter 3 - International perspectives on university innovation

An overview on international perspectives of university innovation activities is presented. Countries selected for the study were Australia, Canada, Japan, India, the United Kingdom and the United States of America. The reasons for the selection of these countries was due to their intellectual property systems, policies and structure which added value to the study.

Chapter 4 - Intellectual property, economic development and university industry collaboration

Commercialization activity, including protection and technology diffusion, is covered in this chapter. The route of commercialization and the impact on economic development is reviewed. The motivation for university industry collaboration, together with the challenges, are investigated.

Chapter 5 – Higher education and intellectual property in South Africa

This chapter focuses on the Government's role and support structures for intellectual property rights protection within the Higher Education sector in South Africa.

Chapter 6 – Research methodology

The design and the methodology employed for this study are clearly outlined, which includes: sampling techniques; research instruments; data collection and analysis; and ethical considerations.

Chapter 7 – Results and data analysis of questionnaire

Data analysis and the interpretation of results are presented, with a discussion pertaining to the findings from the questionnaires.

Chapter 8 – Results and data analysis of interviews

Data analysis and the interpretation of results are presented, with a discussion pertaining to the findings from the interview session with innovators.

Chapter 9 – Conclusion and recommendation

The study culminates with the conclusion and recommendations to increase the commercialization of university innovation. This is followed by suggestions for further investigation and research.

1.9 Conclusion

This chapter provided a comprehensive overview of the study. A background of the transformation and evolutionary phases of the commercialization of university innovation was discussed, highlighting some of the challenges facing HEI's. The alignment between innovation and the strategic commercialization needs of universities was highlighted. The global economic impact that the commercialization of university innovation has on new technologies was also discussed.

The next chapter conceptualizes the study within the public management ambit, new public management and HEI's. The importance of intellectual property rights and related legislation in higher education and industry collectively are raised. Intellectual property challenges within the higher education sector and the importance of academic entrepreneurship will also be highlighted. The review of the literature in the next two chapters is important to better understand the underlying themes, integrate the pertinent findings, and identify avenues for success in the commercialization of university innovation.

Chapter 2

PUBLIC MANAGEMENT AND HIGHER EDUCATION

2.1 Introduction

The previous chapter provided a background to the research study. The research problem, significance of the study and the study design were briefly discussed. This chapter reviews public management, new public management, HEI's and legislation relating to intellectual property.

Since universities collectively form the largest concentration of skills and personnel in the area of knowledge generation, then new knowledge, ideas and innovation are likely to derive from within them. Sun and Baez (2009: 8) argued that IP has become essential to higher education because of the economic, political and social forces that make knowledge and research serve as central commodities in the information age. It is therefore important to gauge the extent to which such IP is converted into useful products and services. Public management entails decision-making relevant to the utilization of public funds and infrastructure through efficient and effective processes. As part of the public management domain HEI's not only aim to serve the public interest with educational objectives, they also focus on the receipt of revenue from the Government through the exploitation of intellectual property created by university researchers.

Aside from teaching and knowledge generation the transfer of knowledge is what academics do, however the core mission of HEI's has become far more challenging than in the past. Van Dusen (2013: 3) advised that the primary justification for adding commercial value as a component of the university mission relating to the dissemination of knowledge, is that it promotes technological development for the benefit of society as a whole. Bubela and Mishra (2014: 256) attested that in the case of knowledge dissemination the profits, royalties and licensing agreements drive the university research machine, and not research for the sake of research itself. Academic staff, who in previous years may have been hired for their teaching skills or basic science research ability, may now be hired with a focus on expertise in a particular field for the specific purpose of developing intellectual property which can result in commercial application (Van Dusen 2013: 6). The focus of higher education has changed and it no longer sees itself as being devoted merely to education and research. Currently the mission and goals of higher education include the commercial application of intellectual property. The modern university model is now focused on including a profit-generating research mission which is emphasized in a major way by the role of innovation. Attention to converting research into commercial application for the purpose of remaining competitive will continue, however, to be the model for research intensive institutions of higher education in the future. New knowledge discovery, patenting, disclosure, licensing and the assignment of intellectual property rights are some of the challenges faced by institutions of higher learning and teaching.

2.2 Public Management

Public management focuses on government and non-profit administration. Public management is meant to be understood as performing certain tasks related to policy implementation in publicly supported programmes. Education, being one of the sectors of public management, plays a critical part in influencing and contributing to the economic development of the country. Based on the BATHO PELE principles, the Department of Public Service and Administration (DPSA), in consultation with stakeholders such as universities, formulated a strategy for human resource development. The strategy included the vision of a dedicated, responsive and productive public service, with a mission to maximize people development, management and empowerment through skills development to accelerate transformation and service delivery to benefit the people of South Africa (Tummala *et al.* 2010: 10).

Wigg (2000 cited by Van Tonder 2002: 6) suggested that the current and future developments in public management are being shaped by the ‘knowledge society’, whereby public service delivery takes place in a context that is increasingly characterized by widely accessible information, greater demands and complex tasks that require knowledgeable employees. Khosa (2010: 2) asserted that in establishing the value of the investment made in education (accountability), identifying areas that can be improved and establishing how systems work (research) will contribute positively to the general public management sector and service delivery.

Public management is part of the broader academic field of public policy. In trying to achieve public good, and as stated by Rajah (2013: 7), the public manager must deal with critical infrastructure issues that affect the quality of life. These issues include the sponsorship of university research; the ownership of research discoveries; the dissemination of new knowledge; and technology transfer policies. Van Dusen (2010: 3) raised the issue of whether universities will allow commercial forces to determine their educational missions and academic goals. As research initiatives from Government funded sponsorship at universities continue, the dissemination of new knowledge is on the increase. The role of innovation is important in achieving national objectives which contribute to improving the quality of life of citizens, thereby adding to the promotion of sustainable economic growth and international competitiveness.

Ideas and expressions translate into commodities, therefore the management of such intellectual property needs to be nurtured for economic growth. According to Powell and

Rhoten (2011: 7), the patenting and licensing of IP by universities is closely regulated by national policies emanating from the dominant role of government in funding academic research. Intellectual property is of great value because of economic, political and social forces making knowledge serve as central commodities in the information age. This is supported by Palfreyman (2011: 3), the Director of the Oxford Centre for Higher Education Policy Studies, who argued that IP is of significant value as it is “usually assumed and asserted that research, with related intellectual property exploitation as technology transfer, is the key contribution of higher education to economic growth”.

In the USA federal policy underwent a major change through the Bayh-Dole Act of 1980, which fostered greater uniformity on the way research agencies treat innovation arising from the work they sponsor. This allowed universities to take title in most circumstances, thereby accelerating patenting and licensing activity. Although the system created by the Bayh-Dole Act has remained stable, it has nevertheless generated a great deal of debate about its effectiveness and whether it has produced unintended effects that are adverse to other modes of technology transfer and even to the norms of the university community. South Africa’s Intellectual Property Rights Act 51 of 2008 was similarly motivated and has faced similar challenges. The higher education sector is therefore required to be accountable for its performance, and in doing so needs to be monitored and evaluated to ensure continual improvements and that targets are maintained.

2.2.1 Government and higher education

Feleke (2012: 1) declared that higher education and universities are the products of the political and socio-economic systems in which they are embedded. Globally the political transitions have had a number of positive consequences on higher education systems. It has been noted to have increased the pressure on higher education to become more accountable. Managerial practices and accountability mechanisms from the corporate sector have been imported into public institutions and universities. Profitability rather than sustainability seems to be the driving ethos of universities. The role played by the public management sector is enormous for the total development and continued improvement in the country. For public service to succeed, the requirement to fulfil the mandate of providing efficient and effective service delivery is to increase its investment in training and development, as well as orchestrating more involvement by universities (Tummala *et al.* 2010: 10). Although these initiatives may be in place, Thornhill (n.d.: 4) stated that there are still inhibitions in progress or development due to lack of properly trained and experienced managerial public servants to operate within the system.

Variations are found between the systems of innovation in different countries, all of which have their own set of challenges and success. For example, Australian HEI's have a well-developed system that focuses on adding value to key primary products in the mining and agricultural sectors, with laboratories that are strongly subsidized by their Government. Finland has a system that is comparatively different from other countries, which emphasizes funding instruments focusing on promoting research collaboration between higher education and the business sectors. The strong emphasis is on human capital and industrial innovation. Chile has changed a mixed system of Government laboratories and universities to a system similar to the Finnish model. South Africa has a mixed research and development system performed by the private sector, higher education and government. Although each country has its own innovation model, the ultimate goal of each system being the quality of life for all citizens and economic growth and development remains common to most. Research undertaken at universities with public funds has the potential of creating new innovation that may have commercial application. Universities are therefore seen as knowledge producers and a source of new innovation. Some country's Governments have mandated universities to set up offices to deal with IP-related matters. Universities are expected to manage IP appropriately where such arises from government funds, or at the very least are required to furnish proof of commercialization and licensing attempts.

As a result of the expectation of universities having to report to the Government on the usage of publicly funded research, new reporting structures in keeping with the new public management system has to be adhered to in most countries. In the 1980's countries such as England, Australia and England challenged the traditional bureaucratic public administration model of Max Weber. Chipkin and Lipietz (2012: 1) revealed that the old school or 'traditional model' of public management and administration came under scrutiny. Kalimulla, Alam and Nour (2012: 5) concurred, stating that traditional public administration all over the world failed to take cognisance of some vital environmental forces in spite of its importance. The accountability of universities for the correct management of innovation arising from public funded research is therefore of vital importance. The new model of public sector management emerged in response to a number of environmental forces. Globally governments engaged in widespread and sustained reforms of public management as a result of economic recession, which were influenced by political and social drivers. These changes and reforms became known as new public management (NPM).

2.3 New public management

Cameron (2009: 3) believed that NPM was inspired by the values and concepts of the private sector and was seen as a way of cutting through the red tape and rigidity associated with old-style public administration, to promote more efficiency and effectiveness. Tolofari (2005 cited in Ferlie, Musselin and Andresani 2008: 7) contended that NPM had a great international influence, being a well-known public sector reform that emerged in the United Kingdom. The global performance of NPM quickly spread from the country of origin to other regions, having an influential impact on government policies in developed and developing countries (Tolofari 2005: 75). Public service reforms were evidence of the effort to improve public sector administrative structure and operations. In the early 21st century 'New Public Management' became the dominant theme. Public administration services have transformed since the emergence of the NPM shift. The focus was on the manner in which services were offered, while reforming the quality of service to citizens and businesses. The efficiency of administration in general was increased and was referred to as the 'back office' of the Government.

Chipkin and Lipietz (2012: 1) declared that the last two decades have been associated with a fundamental shift in the principles of public sector management in all industrialized countries. One of the aims stemming from that shift was a general reinvention of the role of Government sectors, in order to reassess service delivery and to ensure that employment sectors functioned at an optimal level. Vyas-Doorgapersad (2011: 1) reported that the progression from public administration to NPM stimulated intellectual debate amongst scholars, thereby raising probing questions. Such questions focus on whether NPM should be regarded as a new paradigm and whether there are marked differences between NPM and public administration, as well as whether there are differences in approach or if they complement each other. To attempt to answer these probing questions, NPM is seen as a body of managerial thought (Larbi 1999: 12) or as an ideological thought system based on ideas generated in the private sector and imported into the public sector (Larbi 1999: 12). Theoretical breakthroughs and the reconstruction of new theories emerge more readily when competitive approaches are allowed to co-exist (Lan and Anders 2000: 162).

The recent decade has witnessed changes in public governance in Western Europe, with reforms focusing on cutbacks, deregulation and privatization (Pollitt and Bouckaert 2000 cited in Longman 2011: 3). Some of these reforms have been inspired by NPM, which has altered the structure and policy-development process in public-sector organizations with the purpose of making them more efficient and effective. The NPM approach is also seen as a new paradigm to promote the principles of decentralized, democratic and free-market orientated government. Chipkin and Lipietz (2012: 1) argued, however, that this new paradigm implies that traditional public administration was not democratic and free-market orientated and failed to improve the institutional, administrative, generational and structural contexts in Africa. New public managmeent can also be seen as a "paradigmatic break from the traditional model of public administration" (O'Flynn 2007: 353). It is a reformed public sector transformation that breaks away from the repressive, autocratic and conservative paradigm of public administration that followed top down hierarchies "underpinned by Weber's (1946) bureaucracy, Wilson's (1887) policy administration divide, and Taylor's (1911) scientific management model of work organization" (O'Flynn 2007: 354). New public management is not a well-defined or coherent set of ideas (Wegrich 2012: 1), therefore analyzing the impact is difficult and not straightforward. Since aspects such as efficiency, effectiveness, accountability and social cohesion are difficult to assess, it merely reflects a number of changes in public-sector management style. Many of these changes were not strategically planned or implemented at a precise time and could, therefore, have attracted unintended adverse effects.

Stemming from the concept of NPM, the production of goods and services previously seen as the natural domain of the Government came under scrutiny. Stricter control strategies had to be implemented. The main objectives of public sector reform were "to achieve better delivery of the basic public services that affect living standards of the poor" (Omoyefa 2008: 18), and "to make the state or government institutional apparatus market friendly, lean, managerial, decentralized and 'customer' friendly (Omoyefa 2008: 19). These components of NPM emerged because "many African countries such as Ethiopia, Ghana, Mauritius, Senegal and Uganda, embarked on comprehensive reforms aimed at improving the quality of life of their citizens, and creating new government machineries to establish efficient and effective management systems" (Economic Commission for Africa

2004:1). Some changes were reported to have been more fundamental than others, which appear to have profoundly changed the nature of the public sector. Other changes were seen as more marginal implementation, although it was also noted that attempts at reverting or reintroducing older ideas were reported when NPM proved unsuccessful. Numerous analyses of NPM indicate that resorting to public/private partnerships is far from always being advantageous to government, giving rise to uncertainty and possibly increasing costs for the public sector (Sigman 2008: 2). Stromme (2014: 47) advised that the consequences of importing private management standards into the public sector would be difficult to predict. This is because the chain of interdependence is much more complex than the standard vision the 'NPM' theory supposes.

The attempt at implementing management ideas from the business and private sectors into universities and other public services was noted as the start of the change to NPM. Longman (2011: 7) highlighted some key findings in a comparative study between English and Dutch universities on the effects of NPM within university practice. Their findings indicated that university management and external regulating agencies increased the pressure to perform and to be accountable. This resulted in further pressure to collaborate and compete for resources in search of excellent human capital. The pressure for high performance from funding agencies and university management was a major concern for academics. This was partly due to the fact that management of IP emanating from publicly funded research became a critical factor in ensuring that the public derives greater returns from the increasingly significant research and development investments made by the Government. Productivity, marketization, service orientation, decentralization, policy and accountability were identified as key ingredients to start the change at public service organizations such as HEI's.

2.4 Impact of new public management on higher education institutions

Higher education, and in particular universities, have undergone a profound transformation in the past three decades. From a public management perspective, HEI's collectively also formed part of the NPM reform. Tolofari (2005: 83) confirmed that along with every other sector the education service, being one of the major public service providers together with health care, law and order, was also reformed. Furthermore, according to Tolofari (2005: 84) HEI's leaned towards the fully-fledged corporate organizations delivering enterprise education and managerialism, which was flagged by 'a new kind of executive power'. Decisions that were previously made by regional or national Government about the allocation of resources were now being taken by universities. For example, universities were now faced with the pressure of raising the level of non-State income, which led to a greater adoption of business methods and the creation of the quasi-markets (Ferlie, Musselin and Andressani 2008: 3; Tolofari 2005: 84).

New public management seeks to produce a smaller efficiency- and results-oriented public sector. Ferlie *et al*. (2008: 327) highlighted the signs and symptoms that were predicted in terms of the application of NPM ideas to HEI's, which relies on:

- **Market based reform -** Research remains largely in the public domain where the ideas are widely held and everyone owns them (Sanders and Shepherd 2012: 1). It is blocked by the economic social character of higher education and research with the public good nature of knowledge and the indirect character of most of the economic effects of education and the character of status competition. The goal of NPM market reform is that educational institutions must perform as business firms, producing economic products within an open competitive market (Marginson 2009:

1). Competition for students between HEI's, such as the development of real 'prices' for teaching fees, forms the basis on which trading in the market takes place. The introduction of higher student fees to empower students as consumers and to drive up teaching quality levels can be seen as quasi-market based reform for public higher education and research institutions.

- **Strong performance measurement, monitoring and management systems, with a growth of auditization, a variant of NPM -** Pausits, Zheng, and Abebe (2013: 2) stated that stakeholder guidance concerned activities which direct universities through goal setting and advice. Academic self-governance concerns the role of professional communities within the university system. Managerial self-governance concerns hierarchies within universities as organizations. Competition for scarce resources, money, personnel and prestige within and between universities takes place on quasi-markets where performance evaluations by peers substitute for the demand pull from customers. There is emphasis on financial control with efficiency and value for money. The transformation of goods and services, ideas and activities for example, includes the introduction of intellectual property rights that generate income.

- **Empowered and entrepreneurial management rather than collegial public sector professionals and administrators -** This is influenced by ideas in organizational economics such as principal theory, which stress incentives and performance. There is a concentration on goals of efficiency, value for money and performance rather than democracy or legitimacy. The main thrust is to shift power to consumers and managers. In the realm of governance, the development is of strong rectorates and non-executive members drawn from the business sector. There is a change from elected to appointed senior posts. There is also a reduction in the representation of faculty and trade unions in HEI governance.

Universities are expected to increase their entrepreneurial skills to compensate for budgets cuts. Government views universities as utilizing large amounts of public funds, and therefore demand cost-cutting measures which force universities to generate third stream income because of dwindling state subsidies (Duke 2002 cited in Tolofari 2005: 84).

Even in South Africa, the adoption of new public management is common. Prior to the democratic period and during the apartheid era (pre-1994), the South African public service was isolated and out of touch with international developments (Thornhill n.d cited in Cameron 2009: 5). Higher education institutions in South Africa had to increase their income to supplement dwindling Government subsidies. Views expressed by Habib (2014: 38) highlighted that South African universities are under-funded by approximately R15 billion when compared with HEI's globally. Since public universities in South Africa had to generate third stream income to supplement resources, increased attempts at the commercialization of innovation was seen as a solution (Nayyar 2008: 9). Accountability on the generation of third stream income from publicly funded research arises from the impact of NPM.

Van de Walle and Hammerschmid (2011: 3) stated that the impact of NPM had resulted in advantages and challenges due to two factors: "one is that many reforms are not clear-cut but rather emerge or remain undefined and combine many NPM- and non-NPM-style reform elements. The other is that New Public Management as a concept has different meanings and has therefore become a catch-all term, making it hard to evaluate its impact". In a study by Bebravicius (2012: 6) in Lithuania, the results highlighted six elements that underpinned the management approach: namely, decentralization; privatization; orientation of the results of the market mechanism towards the public sector; private sector management practices; and the introduction of participation. Bebravicius (2012: 7) reported that all the concepts of the Lithuanian higher education legislation have been characterized as consistent and meet the six elements of NPM. The impact of NPM in Lithuania is reported to be positive, which includes the impact on their HEI's. With an increased focus on intellectual property activity and accountability for the generation of third stream income, the negative impact of a dwindling State subsidy on the higher education sector has been reduced (Bebravicius 2012: 9).

According to Meek (2011: 4), within the higher education sector funding declined significantly since the implementation of NPM. The focus on entrepreneurial university excellence, with goals such as productivity and efficiency, and participation in IP activities increased university output. Universities were forced to redefine their institution's mission and goals. Added pressure on universities were caused by "governments introducing NPM in the hope of maximizing output, while reducing unit cost, and in the process shifting the accountability for achieving these ends to the institutions themselves" (Meek 2011: 5). It was hoped that market steering would enhance accountability and efficiency, while reducing the financial burden of higher education on the public sector. In this regard Davies (2012: 7) confirmed that Australia provides similar examples of where NPM and market competition have replaced many traditional forms of academic governance, with responsibilities devolved to universities. This found institutions under pressure to strengthen their managerial skills and to become more entrepreneurial and corporate in nature (Davies 2012: 8).

The need for countries to be competitive in the global knowledge economy has been encouraged by the changes in governance. Ordorika (2009: 2) argued that globalization has modified the changes and expansion of markets, particularly in education and knowledge production. The increasing economic globalization process created new challenges for HEI's, which impacted on their relationship with society and their management and governance systems (Meek 2011: 1). The introduction of market-type regulatory mechanisms was accompanied by substantial changes in university governance. The emergence of NPM, as stated by Davies (2012: 3), induced a movement towards governance mechanisms within higher education similar to those of the private sector. It was observed that decreasing collegiality and increasing concentration of top level power emerged, with university boards consisting of decreased internal membership and increased external participation a noticeable trend. Despite the new governmental rhetoric of increased autonomy for higher education, these developments are a reminder of the words of Mahony (1994: 125), who stated that "the 'new' autonomy is then a paradox: it is the autonomy to be free to conform". Higher education institutions needed to focus on the effects of production driven policies, the impact of the decline of funds on the goals and mission, and the detrimental consequences on the social responsibilities of the university.

New public management was originally introduced in an attempt to remedy the main concern of cost-cutting and to improve efficiency. Changes were brought about which included the restructuring of higher education sectors by importing private management standards. What remains to be established is whether the eventual outcomes have been particularly positive. While managerial style did have a positive impact on the short-term economy and efficiency, it also created new problems of fragmentation and co-ordination. The NPM thinking did instill increased entrepreneurial spirit into the public sector, but may also have had negative effects on equity and social cohesion. Factors of concern are due to many reforms not being clear and remaining undefined. The concept has different meanings and therefore it may be difficult to evaluate its impact. With the pressure to restrain an ever-increasing public expenditure, Governments launched schemes to cut back the public sector, knowing that these changes were unlikely to be popular. They have packaged the programmes of reform that promise "more with less" (Hood 2011: 738). This has resulted in a number of intended and unintended effects. The UK remains a key index case for NPM and an exporter of NPM reforms. Within the UK, specific public services varied in the timing of the importation of key NPM ideas and in the capacity of the centre to impose them on the field. The influence of NPM extends beyond the UK. Literature reveals that the emergence of NPM in the USA, UK, Australia and New Zealand revolutionized the traditional public administration model of Max Weber and Woodrow Wilson.

2.5. Intellectual Property within Higher Education Institutions

Education and teaching, knowledge generation and the transfer of knowledge are the core business of academics. Previously, it was generally accepted that knowledge dissemination from research was of vital importance rather than generating profits. The focus has shifted, however, to include the generation of revenue through the exploitation of IP created by university researchers. Once the creation of knowledge with commercial potential has been identified, universities utilize their technology transfer offices within the institution to assist in matters associated with IP licensing and commercial application. This type of practice within higher education structures has altered the use of knowledge at universities. Knowledge was previously used for teaching and development, whereas knowledge is now seen with a new focus of revenue generation. This is supported by Van Dusen (2013: 1), who argued that the redefinition of the use of knowledge within the higher education sector is the direct result of economic, political and social forces. Sun and Baez (2009: 10) declared that the economic, political and social forces are shaped by prevailing factors of legal parameters, new technologies and competing interests that contributes to practices at universities.

2.5.1 Emerging concerns over intellectual property rights

The rise in university IP activity such as the registration of patents has occurred against a broader policy framework aimed at fostering greater interaction between academic institutions and industry, in order to increase the social and private returns from public investment in research. This has therefore forced HEI's to become critically engaged with intangible objects. The attention focused on IP assets at HEI's has accelerated and reached a high priority for administrators and university management. Policies and regulations associated with IPR's had to be incorporated into the institution's goal and mission statement.

Intellectual property rights offers protection for valuable assets that have the potential of attracting large financial rewards for its utility. Over the last three decades, universities both locally and internationally have become more involved in the management and commercialization of intellectual property. This includes obtaining funding for academic research from private investors, the licensing of IP, and serving as a liaison for economic development for local communities. Baxter (2011: 14) highlighted that such research and discoveries often results in conflict over ownership in the absence of proper university policies. The overall transference of academic innovation from university to industry for the purpose of commercialization is found to be a challenging process. Universities have been faced with complex matters associated with the management of intellectual property, and have found them difficult to action. This is supported by Sun and Baez (2009: 84) who argued that issues such as identifying potential intellectual property in new research work requires the attention of an intellectual property specialist. Other areas of concern for a specialist to manage includes the ownership of IPR's, the licensing of innovation, and the distribution of royalties on income generated. The legal, technical and competing interests associated with IP are complex matters to manage.

2.5.2 Conflict over protection of intellectual property rights

The decision to apply for IPR over academic work presents itself with conflicting issues. Baxter (2011: 11) argued that intellectual property protection ensures attribution of the work to the innovators and allows the university to facilitate scientific progress over industry. The interest of innovators are maintained, which generally serves the public interest.

On the contrary, however, some university researchers believe that IP protection is counter-productive to the role of universities as public service providers. It is argued that IP protection creates data blockages, such as keeping data a secret, which shifts the research focus from basic towards applied research. This in turn causes problems with patent thickets and passes greater costs to the end-user, being the consuming public (Foray and Lissoni 2009: 6). The increased cost on end products is a direct result of the effect caused by IP protection with high patent registration costs. Intellectual property protection on publicly financed innovation at times contradicts the statement of the public good. Sweeney (2012: 6) asserted that the effects of IP protection on publicly financed innovation has affected research practice and norms of science, created ‘anticommons’ problems, and contributed to patent hold-ups which have led to increases in consumer prices. Products of value to the taxpayer, such as green technologies, are often owned by private investors and sold at a higher cost because of IP protection legislation, which otherwise would have automatically entered the public domain (Ouellette 2010: 1729). It must be noted that research at public university are subsidized by public funds. Publicly financed research funds from the Government is ultimately the taxpayer’s money (public funds). This translates to researchers being subsidized in their research efforts by the public purse. Ultimately, the consuming public pays more for new technology which was initially subsidized by the public purse.

2.5.3 Factors influencing IP practices within higher education

Intellectual property has become essential to higher education because of economic, political and social forces making knowledge and research serve as central commodities. Ficsor (2010: 3) commented that although each force by itself plays a role in shaping policies and practices toward intellectual property, collectively they represent the larger environmental conditions that affect the legal parameters, technological advancements and competing interests that shape the policies and practices surrounding the treatment of intangible discoveries at HEI's. As competing interests emerged, HEI's responded with intellectual property policies and practices as shown in Figure 2.1. Economic, political and social forces allow knowledge and research to serve as central commodities in the 'information age', making intellectual property assets essential to higher education. Policies and practices at universities contribute to the shape of intellectual property rights at universities. The manner in which the information age has altered the management of IP, together with the economic, political and social forces in higher education, is an important consideration as illustrated in Figure 2.1

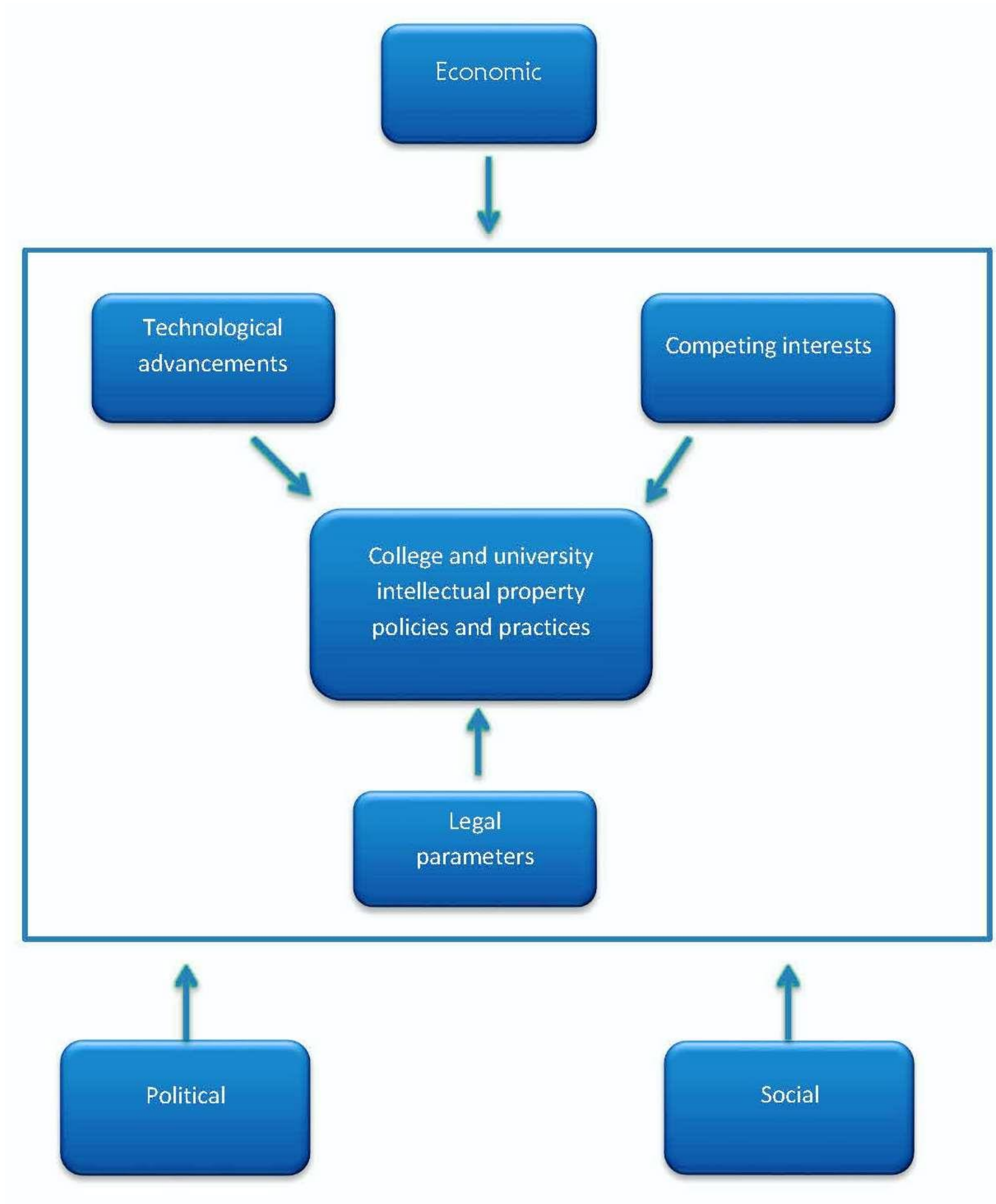

Figure 2.1 Factors influencing IP practices within higher education (adapted from Sun and Baez 2009).

- **Economic forces** – As outlined by Bazid (2011: 17), economic trends make the consideration of intellectual property imperative for a broader understanding of the forces that shape the treatment of creations and discoveries derived at HEI's. Ideas and expressions become commodities and universities must contend with the legal parameters, technological advancements and competing interests that alter the policies and practices surrounding the treatment of intangible creations and discoveries. Schoen (2011: 21) elaborated that IPR's are the legal means by which one can protect one's investment in innovation prior to the commencement of developing, commercializing and exploiting scientific and technological innovations. The complexity of dealing with intellectual property in the information age has therefore become complex within higher education. One of the reasons is that some believe IP registration hinders the sharing and open source information, therefore more and more researchers are withholding research results with preliminary discoveries and confidential formulas. This affects intellectual property policies and slows down publication output.

- **Political forces** - Murray (2004: 6) stated that political forces, laws and policies reward innovation. Thus, it is the political structures that form national priorities that stimulate innovation and define IPR's. National systems of innovation places universities at the forefront as participants which harvest discoveries and creations with publicly financed funding (Sun and Baez 2009: 4). Intellectual property assets have become extremely important to universities because the innovation developed by university researchers plays a crucial role in political-economic exchanges, generating potential revenue, and decreasing universities' dependency on the Government subsidy. Universities have therefore increased their intellectual property activity, seemingly transforming themselves from knowledge producers for the public good into intellectual property producers for profit (Baez 2005: 7).

- **Social forces** – During the information age, IPR's addressed what was understood as the 'public good problem'. This ensured that innovators had an economic incentive to create innovations that ultimately benefit the public (Litman 1990 cited in Sun and Baez 2009: 5). In the USA the Government grants IPR's primarily to promote public interest of access and use, balanced by incentives and rewards to inventors (Wallerstein, Mogee and Schoen 1999: 8). The protection of intellectual property is critical for universities as discoveries and creations contribute to the public good in the form of solutions to societal problems. Jobe (2006: 9) recognized that while IPR's are known to restrict the public from using an innovation without permission, it prevents others from developing and improving on innovations thereby limiting further benefit to the public. In theory, IP systems are necessary to encourage creative endeavours in the interest of public. Although in practice, an IP system is considered a barrier to the flow of knowledge and innovation diffusion.

Social, political and economic forces changed how universities manage their intellectual property assets. These forces are shaped by three primary factors that directly contribute to intellectual property policies and practices at universities, as illustrated by Sun and Baez (2009: 6) below:

- **Competing interest** interferes with the traditional functions of HEI's in ways that was not previously experienced. As the law establishes ownership and control over works, competing interests from individuals and sometimes groups also contributed to the crafting of IP policies and practices at HEI's (Bobbitt 2006: 2). An example as explained by Sun (2008: 5), is when ownership over online courses emerged as a central question within higher education and the interests of institutions, students and faculties emerged. As competing interests began to grow, universities therefore responded with IP policies and practices.

- **Legal parameters** are laws pertaining to IPR's which form the base of policies and practices at HEI's with regard to innovation. Sun and Baez (2009: 6) posited that laws associated with contracts, country employment relations, sovereign immunity and international treaties are contributing parameters to an institution's policies and practices. For example, under the copyright law the default rule indicates that the author holds ownership rights to expression; however contract law permits the author to negotiate the ownership rights with contracting parties. Legal parameters extend beyond IP laws and touch on other laws which contribute to an institution's IP policies and practices, such as contract law.

- **Technological advancement** contributes to the language of IP policies and practices at HEI's. The example as quoted by Sun (2008: 11), indicates that current electronic technologies enable delivery of courses online. These courses may represent expressions of content that qualify for IP protection, primarily because unlike traditional courses it can be 'fixed' into a tangible form in keeping with copyright laws. This is outlined by Levine and Sun (2003: 17), with the example that teaching online courses qualifies for copyright protection and affects IP policies and practices at institutions of higher learning.

Each of the mentioned factors are found in variation within university policies as dictated by IP legislation in respective countries. As legal parameters, technological advancements and competing interests are direct factors that contribute to the formation of intellectual property regulations at HEI's. They impact on core academic functions, particularly in terms of teaching, and research activities are required to be compliant with such legal parameters. In summary, it can be seen that the exploitation of discoveries and knowledge dissemination generates both private and public good, and that the one element impacts and enriches the other. It is also important to note the crucial role played by universities in society, as this impacts on economic competitiveness internationally. Institutions of higher learning need to manage a balance in ensuring compliance and how the potential risks and rewards offset each other. These considerations have considerably changed the role of higher education practices.

2.6 Higher education and intellectual property policy

It is generally accepted that a country's IP in the form of the number of patents granted to its nationals, can be used as a proxy for both the extent of innovation and for current and future economic growth potential (Sibanda 2008: 30). Among the different types of intellectual property protection measures, patents are accepted internationally as a reflection of a country's inventive and technological achievements. The main focus of this study is therefore directed at patents, as this represents the most significant facet of IPR's for higher education in the information age. The role of IP policies and practices in HEI's includes finding ways to balance multiple goals; this includes creating incentives for innovation, protecting interests in innovation and discovery, and legally complying with the appropriate use of protected work (Munzer 1990 cited by Ostergard 2012: 7).
The discovery and dissemination of new knowledge has always played a critical role within a university's mission. Knowledge, in the form of publications, conference presentations, tangible and intangible assets, is a measure of success for the university and the academic researcher collectively (Baxter 2011: 24). The manner in which such IP resulting from publicly funded research is managed, has become a challenge for institutions of higher learning.

The generation of revenue through the exploitation of IP assets has become an important point of focus for higher education. University IP policies include a statement of mission and objectives. The main purpose for such policies defines the ownership and distribution of revenue generated through commercial activity. As the Bayh-Dole Act did for America, similarly, the South African IPR Act precipitated efforts by most universities to establish or refine policies defining the respective rights to own, use and profit from intellectual property. For example, Van Dusen (2013:4) declared that Boston College's policies recognizes that "scholarly and research efforts often have social and commercial implications" and explains that its policy is designed to "define the conditions of ownership, legal protection, development and licensing of intellectual properties conceived or first reduced to practice by any Boston College employee or student". Van Dusen (2013: 5) further stated that Harvard University has a similar approach, but then clarified the importance of exploiting the possible financial windfall by stating in its policy that, *"although this policy recognizes that public benefit comes before financial gain, it is appropriate and desirable for the university, inventors and authors to benefit financially from creative work."*

A common situation that universities find themselves in is where an innovator believes in his/her entitlement to a vested right of ownership. As explained by Van Dusen (2013: 7), creators and inventors of intellectual property often rationalize that if they invented a product, then they should own it. Most policies of HEI's, however, alters this assumption. Tension presents itself between the innovator and the university at the stage of income generation and the distribution thereof. University polices must be drafted in a manner that clearly defines the ownership of rights, so that researcher and university management may amicably resolve matters. Generally, when innovation is created on the instruction of the institution by its researchers utilizing public funds the IP policy in all probability regulates the ownership and distribution of income that may be generated.

2.7 Intellectual property challenges within higher education

Higher education reform is a worldwide phenomenon induced by internal and external environments of higher education functioning. Vandeyar (2010: 1) proffered that transformation in higher education is leaping outwards to fulfil the criteria set by international competitiveness and related efficiency criteria, which can be attributed to globalization pressures. This is supported by Gordhan (2012:2) who indicated that some of these challenges include internal and external pressures for accountability and transparency in the management of the institution's finances (Gordhan 2012: 2). Since the change to NPM, universities in many countries have been experiencing declining State subsidies. The low graduate throughput and declining enrolments contribute to the challenges faced by HEI's. Universities are further faced with competition from global counterparts. Limited partnership between industry and the Government, bureaucracy and a lack of support from management at institutions of higher learning results in poor service delivery in general. In this regard, the higher education sector is faced with multi-dimensional challenges.

Over the last two decades higher education, an environment critically engaged with intangible objects, has been increasingly engaged in innovation, IPR's and the commercialization of discoveries. The overall process of converting academic innovations into products for transfer to the marketplace is complex and fraught with challenges that result in conflict and tension between the innovator and industry (Baxter 2011: 16). The role of IP in higher education has changed considerably, requiring a focus directly on assets as part of research administration and legal protection.

Re-established or new IP legislation has enabled institutions of higher education the right to own intellectual property generated by their researchers from Government grants. As a result, HEI's and innovators have generated profits from Government-supported research with commercial value. The dissemination of profit-oriented research results raises concerns on the free exchange of knowledge, however, and the possible negative effects to which universities are willing to undertake research without such funding. Further, universities have become actively involved in generating revenue from IP as a direct result of declining subsidy from the Government. Government funds that were previously assigned to higher education have been redirected to higher priorities of concern within countries.

Lever (2012: 4) stated that universities are now expected to address complex legal questions pertaining to intellectual property to which suitable solutions are required to be found. Sun and Baez (2009: 7) outlined some of the questions posed, for example: What is intellectual property? Who can own the products of knowledge? How are the various legal, technical and competing issues associated with intellectual property to be dealt with? The topic of intellectual property is, by its very nature, highly complex. The issue of IP ownership would prove to be just as complex as it is regulated by an Act in each country. Sanders and Shepherd (2012: 1) explained that society must accept a broader concept of property ownership if it is to recognize and protect an IP right. Ownership refers to whom credit is given for the origination of an idea, or to whom the right is given to exclude others from using that idea. The challenge is that ownership privatizes ideas and creations, thereby making it inaccessible to others. The question of ownership of patents is generally the most difficult and complex. Institutions of higher learning are not excluded from the complexities of IP. Traditional models of ownership brought concerns about intellectual property development, use, and application to a new importance in current academic conversations. Under the old way of viewing ownership, single ownership of intellectual property was less complex. In the current environment, however, ownership is complex as new technology encourages the development of products using a variety of input which may involve multiple layers of previous (old) discoveries and new material collectively. The challenge of ‘who owns what’ is compounded when one considers factors such as how much support, use of facilities, and equipment involvement are used to produce an innovation. University ownership policies are guided by legislation pertaining to each country.

Barrow *et al.* (2014: 1) attested that there is a lack of consensus among institutions on how to manage IP generated by researchers at HEI’s. Naturally, policies that are implemented by universities are a reflection of its institutional priorities. It stands to reason that institutions promoting income generation will implement policies that exercise broad ownership over their IP. In contrast, institutions which are less focused on revenue generation may assert little to no ownership over generated IP.

The complexity of the process of academic innovations moving into commercialization has its own challenges and conflict. Baxter (2011: 18) espoused that this is generally due to a lack of knowledge and understanding associated with both IPE’s and the institution’s policies and practices. Other associated issues are whether universities allow commercial forces to determine academic goals and the educational mission. There has been an increase in collaboration between university and industry. Researchers are aware of challenges associated with financial incentives as a result of IP ownership and collaboration with industry partners. Therefore as legislation dictates, universities had to set up IP&TTO’s to manage matters associated with IP rights and the challenges posed by commercial opportunities presented by innovation.

Mazzoleni and Nelson (2011: 132) stated that the lack of clear incentive and benefit sharing formulae left researchers with little or no motivation to innovate and commercialize such innovations. The re-drafting or new IP legislation in countries now provides for benefit sharing to incentivize researchers, which resulted from an approach inspired by the Bayh-Dole Act. It is, therefore, normal practice that each university is entitled to set their individual royalty distribution percentages on a sliding scale which accommodates for the researcher to negotiate his/her portion. This practice has been observed at universities globally. Many universities are known to provide mandates to faculty on an annual basis, the purpose of which is to give notice to faculty members, staff and students of the ongoing importance of the intellectual property policies and effected practices (Van Dusen 2013: 6).

2.7.1 Decision to file for a patent

The decision to patent could potentially inhibit basic research; universities may therefore conscientiously choose not to patent certain discoveries such as foundational research tools, and by so doing assure wider availability in the public domain. Another challenge is that patent registration costs further impact on the university. For IP managers, patent budgeting is one of the most important aspect of their role, yet it remains one of the most difficult. The complexity of patent budgeting is a direct result of the many variables associated with patent registrations. The decision to file a patent locally or internationally forms part of the complex decision-making skills and expertise. The high patent registration expenditure is further exaggerated by a failure to commercialize. Increasingly, patents are granted for innovations or discoveries that are still a distance away from practical application (Mazzoleni and Nelson 2011: 132). Legislative initiatives have effectively enforced universities to apply for IP protection rights on IP that stems from Government-sponsored research. Traditionally, the norm was to place such IP results in the public domain where the ideas are widely held and the public owns them. More recently, it has been noted that Governments globally have increased investments in research and development, thereby encouraging universities to register patents and to commercialize technology.

Governments have also established incubators and prototyping facilities for start-ups. The innovation agendas and precise policies as mentioned earlier differ from country to country, based on national priorities. Twentieth century university academics traditionally did not consider research-related IP as an opportunity for economic enrichment that required the decision to register a patent. An example is the polio vaccine which was discovered in 1954, an innovation worth millions, however the inventor refused to register a patent. The inventor believed that no individual should own or profit from discoveries made about the natural world. A second example is the discovery of the gene-splicing technique in 1973. The inventors resisted patenting as they acknowledged that their discovery depended upon the contributions of earlier scientists' results that were freely available. Thus traditional academics were of the view that knowledge should be placed in the public domain without proprietary restrictions, which limited access.

The examples quoted on decisions to file for patent registration are perhaps still open for consideration regarding innovation for the public good versus commercial value, a critical deciding factor for decision-makers at HEI's.

2.7.2 Governance and leadership

The management of innovation support models depends entirely on the structure at each institution. The results of a study conducted by Oluput and Maharaj (2012: 211) concluded that a challenge for most HEI's in South Africa was the approach of institutional leaders to embrace technology transfer. It is essential that the support structure acts as true partners to build a collaborative environment. The lack of funds, together with the lack of entrepreneurial skill and experience to commercialize IP, are factors contributing to challenges faced by higher education. Strategically, HEI's are expected to focus not just on teaching and knowledge dissemination, but to also holistically include intellectual property issues. Intermittent progress outcomes ought to be assessed by university executives, and more importantly, the incorporation of change in a manner that impacts positively on IP assets. The reconsideration of the management style at universities will contribute in part to progress on the commercialization of intellectual property, thereby resulting in the generation of income (Baxter 2011: 17). Regular reviews of efforts towards attempts to commercialize university innovation should be accepted as an important element of the institution's senior management duties (Manley 2004: 9).

Previously, academic researchers had been hired for their teaching skills or basic science research ability. Academics are now hired with a focus on expertise in particular fields for the purpose of developing intellectual property that results in commercial application (Van Dusen 2013: 3). Higher education no longer sees itself as being devoted merely to education and research. Baxter (2011: 19) affirmed that the transformation of the higher education sector is common throughout the industrialized world. The need to convert research into commercial application is, and will continue to be, the model for higher education. The focus on academic entrepreneurship is therefore critical.

2.8 Academic entrepreneurship

Academic entrepreneurship is defined and developed from various perspectives. Barth (2013: 1) stated that from a traditional perspective, academic entrepreneurship means "university spin-off" or an "institutional transfer of research", or technology to start innovation or venture. According to Beckman and Cherwitz (2009: 88) academic entrepreneurship can be defined as an "intellectual enterprise" in which universities co-operate with local communities to create new values or ideas. Academic knowledge and activities combined with the academic entrepreneur generates job opportunities and in turn creates income, thereby earning a profit. The term 'academic entrepreneurship' according to Barth (2013: 2) is an academic entrepreneur who acts commercially in creating profit from patent development and from the non-commercial scientific publication of research results. Literature on university-industry technology transfer defines an academic entrepreneur as a scientist who engages in the commercialization of research results by patenting and the setting up of a business (D'Estea, Mahdi and Neely 2013: 2).

Entrepreneurial activities pertaining to technology transfer and commercialization begin with an idea generation, which in the end will result in the launching of a product or process. Based on the value of entrepreneurship universities are becoming increasingly entrepreneurial, embracing a mandate for the realization of commercial value from research and searching for new organizational arrangements that bring a closer alignment of scientific research and innovation (Rothaermel, Agung and Jiang 2007: 697). The distance and pathway between the two ends (idea generation and the launch of a product) as suggested by literature is far from simple, but a rather long and sometimes challenging route which requires meticulous planning and management. Activities commencing with innovation disclosure, protection, market viability and funds for a proto-type are all requirements to ensure the success from the start of idea generation to the finish with a product launch.

During the 1980's national legislations were altered to support entrepreneurial activities at universities. The most well-known legislation, commonly referred to as the Bayh-Dole Act, granted ownership of research results from federally funded projects to universities. The aim of this legislation was to accelerate the commercial application of scientific results (Grimaldi *et al*. 2011: 1048). This brought about a change to the university mission that resulted in the evolution of the entrepreneurial university. Universities became involved in multiple activities benefitting their regional economy. The outputs through which research universities enhanced economic development became much broader over time (Varga 2009: 12). Universities are now understood as multi-product organizations and are involved in the transfer of know-how and technological application of knowledge to create and commercialize new products. The entrepreneurial activity of universities has been epitomized by a rise in patenting, licensing and the creation of spin-off companies (Wright *et al.* 2007: 13). This has been as a result of the Bayh-Dole Act. Further, Gulbrandsen and Slipersaeter (2007: 114) highlighted the importance of academic researchers as the engine of the whole technology transfer process. It is generally understood that the research generator is best placed with knowledge for commercial activity and academic entrepreneurship.

Literature dictates that it takes a few thousand new innovative ideas and often only one has a chance of becoming successful. This is supported by West (2013: 39), an intellectual property attorney in California, who reported that “99% fail - even an inventor, whose product is unusual enough to be granted patent rights, faces daunting odds. Only an estimated one out of every 100 patented products ever makes it to the market place and makes money”. This statement is further supported by Porter (2009: 7) who indicated that university investment in innovation commercialization can take between fifteen and eighteen to break even. Additionally, globalization has put pressure on industry and universities alike to commercialize innovations in order to fend off global competition and to expand into global markets. Datta (2011: 3) affirmed that the increased pace in innovating and commercialization not only assists the innovators in becoming successful, but also raises the bar for competitors. The importance of innovation commercialization is evident in practice as well. A study by De Jong, Marston, and Roth, (2015:1) revealed that 43% of university IP&TTO’s reported that the big challenge in innovation commercialization is choosing which ideas to move forward, a sentiment echoed in literature on university IP&TTO’s globally.

University research forms a significant source of innovation and knowledge generation in regional innovation, thereby contributing to economic growth (Friedman and Silberman 2003: 1). Innovations from universities are increasingly important to businesses, however only a few such innovations are successfully commercialized. With increased knowledge-based industries, access to technology is becoming increasingly crucial which therefore moves universities into a central position as a source for new technology and science-based innovation (Philpott, Dooley, O'Reilly, and Lupton 2011: 161). This is complimented by an analysis of Cambridge University spin-outs, which revealed that university spin-outs seem to have a higher growth potential than industry spin-outs (Wicksteed 2000: 76). The importance of increased university/industry collaboration that ultimately requires experienced academic researchers with enhanced entrepreneurship capabilities is therefore clear.

Academic innovators themselves are found to play a significant role in the commercialization of IP, as their research knowledge is of vital importance in the marketing of their innovation. Spilling (2010: 77) recommended that the method of improving the structure within university research-based innovation system requires the need for increased efforts directly involving academic researchers in the transfer and commercialization process. This recommendation was supported by results from an evaluation conducted by the Research Council of Norway (2010: 2). Their findings concluded that university-based innovations revealed:

- The entrepreneurial mindset needs to be stimulated among academics as well as among the students who may become future academic entrepreneurs (Borluag *et al.* 2009: 47). To recruit more academics into a research-based entrepreneurial programme, a broader mobilization within academic institutions may be necessary.

- The entrepreneurial programme needs to be directed towards the beginning of a start-up process, signifying that more resources may be required after the initial startup.

- The proportion of women in technology transfer is significantly lower than expected.

Academic entrepreneurship, university start-up ventures and institutional transfer of research are shaped by different factors. This is supported by D'Este, Mahdi and Neely (2013: 6) who argued that while the identification of commercial opportunities is driven by prior entrepreneurial experience, the excellence of the academic work and the exploitation of opportunities is driven by the extent of previous collaboration with industry partners, cognitive integration and prior entrepreneurial experience. Based on the USA and European experience, universities may be considered entrepreneurial when they are not afraid to maximize the potential for the commercialization of their ideas and create value in society, without seeing this as a threat to academic values (Gibb 2005: 3). Such universities create a culture of innovation that instills an entrepreneurial mindset by building a structure and process designed for stimulating innovation and value in the marketplace.

2.8.1 Pre-requisites for developing an entrepreneurial culture

The culture embodying and championing entrepreneurial attributes has been around for many decades as a concept described as 'entrepreneurial culture'. Entrepreneurial literature traditionally considers risk-taking as an important distinguishing element in entrepreneurship. According to Brockhaus (2009: 1) risk-taking before embarking on a venture is the perceived probability of receiving the rewards associated with the success of a proposed situation. Literature suggests that entrepreneurial culture is related to a number of positive outcomes, such as generating new innovation that improves process and performance in the everyday environment and business. Wong (2014: 28) articulated that entrepreneurial culture emphasizes pursuing change, innovation, risk-taking and opportunities, which indicates that it is a desirable state to an entrepreneur because of its positive relationship to growth, performance and success.

Eesley and Miller (2012: 46) specified that developing an entrepreneurial culture in the university context requires more than just encouraging innovators to take innovative ideas to the marketplace and providing opportunities for venture capital funding. It requires creating an environment that encourages innovation at every turn, both in the classroom and outside of it.

Meyers and Pruth (2011: 351) proposed five core elements that an entrepreneurial university should possess, which include: i) top-down vision; strategy and leadership; ii) clearly defined entrepreneurship learning objectives that drive the curriculum; iii) robust internal and external networks; iv) a culture of innovation; and v) experiential learning and knowledge transfer opportunities.

Entrepreneurship and innovation are among the fastest growing fields of research. Although there has been much debate around the attributes of entrepreneurial universities over the past decade, a decisive conclusion has not been reached as to what constitutes such an entity. There are various contributing factors that feeds the success of academic entrepreneurship which forms part of the discussion that also includes the proposed elements by Meyers and Pruth (2011: 351):

- **Top-down vision, strategy and leadership** - The importance of top-down vision, strategy and leadership at universities is required for creating an organizational culture that encourages innovation (Neumann 2014: 2). The support by university senior management is imperative for the success of academic entrepreneurship. Senior management at universities have a responsibility to champion enterprise and entrepreneurship education. The vision should have purpose and a strategy that supports the university community, and delivers clear entrepreneurial outcomes inside and outside the university that leads to success (National Endowment for Science, Technology and the Arts 2008: 2). This is reinforced by O'Shea and Allen (2005: 7) in stating that the original mission of the Massachusetts Institute of Technology for example, focused on development and practical application which provided the foundation for an entrepreneurial spirit to flourish from the outset.

- **Clearly defined entrepreneurship learning objectives that drive the curriculum -** Learning objectives at universities must be clearly defined to drive curriculum development and design to inspire entrepreneurial skills. For example, at the University of Cambridge a key part of the curriculum is to train scientists into becoming entrepreneurs (National Endowment for Science, Technology and the Arts 2009: 3). The training includes inter-disciplinary opportunities in areas such as technology policy and the strategic management of innovation, specifically. This enhances skills to take innovation from the laboratory to the marketplace.

- **Robust internal and external networks -** Robust internal and external networks are a critical success factor for entrepreneurial universities. According to the National Endowment for Science, Technology and the Arts (2008: 3) personal networking using social networking tools and extending one's reach beyond core areas of expertise, are core entrepreneurial skills that should be facilitated and nurtured amongst researcher and innovators at universities. O'Shea and Allen (2005: 5) reported that UK universities have over a period of time been successful at developing informal internal and external networks between the Government, industry and academia. These networks have increased and leveraged research funding and allowed for the sharing of knowledge, which assists in stimulating high-tech entrepreneurship.

- **Innovation culture -** Universities encourage an entrepreneurial culture by honouring champions and celebrating success through internal and external communications. O'Shea and Allen (2005: 6) stressed that a core element of spin-off activity is the culture within the university, which is referred to as the 'Entrepreneurial Orientation'. This culture champions commercialization activity by directly exposing young researchers and innovators to role models who have successfully commercialized their research. Meyers and Purthi (2011: 3) attested that the University of Oxford has a system that changed the selection criteria of the university to increase their capacity of star scientists to form spin-out companies. Amongst the many different characteristics of entrepreneurial culture, the ability of high-level strategic decision-making and the ability to take risks forms a large part of entrepreneurial success. Continuous improvement of organizational structure, process, product and services, are the core for any business model that helps to maintain entrepreneurship and an innovative culture.

- **Experiential learning and knowledge-transfer opportunities -** Industry experience is an important criteria that benefits entrepreneurial culture. According to Meyers and Purthi (2011: 6) entrepreneurs learn best by working on projects that are relevant to their interests. Training internship programmes should include knowledge exchange mechanisms as opportunities to cross-fertilize industry with academia (O'Shea and Allen 2005: 7). Students should be offered the opportunity to work on project-based assignments addressing real-world entrepreneurial challenges. The Massachusetts Institute of Technology has supplemented a rigorous engineering curriculum with formal and experiential education in entrepreneurship, drawing on the local alumni base and faculty role models (O'Shea and Allen 2005: 7). This positively impacts on the success in commercialization activity at the university.

In the case of Stanford University, its strategy is to attract the best people to do cutting-edge work and to provide an environment that encourages innovation and supports the free flow of information. Flexibility is the key to success in entrepreneurship. Furthermore, Eesley and Miller (2012: 46) submitted that Stanford University understands that catching the next wave of innovation depends on agility and openness to change. The Stanford University developed practices and programmes that have encouraged innovation and entrepreneurship, which continues to evolve in response to the changing needs of society and the marketplace. It was found the approximately 25 percent of the technical innovators took entrepreneurship course at Stanford University (Eesley and Miller 2012: 2). This has enabled Stanford University to approach entrepreneurship from different perspectives, which is the discussion that follows.

2.8.2 Best practice relating to university technology transfer process

According to Stanford University's innovation administrators, their best practice elements are the result of the success of their technology transfer process. These elements are briefly discussed below (Eesley and Miller 2012: 82):

- The practice of keeping the process as close to the faculty as possible is considered fundamental in supporting effective technology transfer. The reporting line is direct to the Dean of Research on the academic side of the university, rather than to business affairs, a practice considered important for their success.

- They aspire to 'plant as many seeds' which translates to the transference of new technology to as many companies as possible. Some technologies will flourish, others will not, but that is for the marketplace to determine.

- Negotiate agreements with long-term relationships in mind. The ability to be flexible positively impacts on success, as agreements are negotiated with the licensee's circumstances in mind.

- Licensing associates are given considerable autonomy to make patenting decisions and to negotiate creative licensing arrangements based on the unique circumstances of the particular individual technology and licensee.

- Associates draft their own agreements in simple English that sets the tone for a long-term relationship with the licensee. The goal is to build strong working relationships between the university and industry, so the spirit of the agreement and the relationship between the parties are as important as the contract.

- Licenses are often in existence for 20 years, during which period many unexpected events happen. Flexibility effectively allows its licensees to change the licenses as circumstances change.

- Continued improved access to information for staff and inventors to expedite technology transfer. Developed infrastructure to streamline operations, improve communications and enable remote access to information.

- TechFinder portal, where individuals can search for available technologies and sign up to be notified of new innovations.

- Research portals allow for the review of the status of industry sponsored research, material transfer and collaborative agreements, and provides innovators access to updated information on IP.

- A customized database for innovators to manage collaboration with industry partners and colleagues both in the office and remotely (including outsourcing activities to employees working on projects).

- Encourage collaboration with other institutions by minimizing the use of material transfer agreements (MTA's). This reduces barriers to research collaboration between academic, non-profit institutions and industry. This has had a national impact, resulting in other institutions adopting Stanford University's practice.

- Innovations are marketed broadly to mitigate conflict-of-interest concerns. Stanford University does not actively participate in fundraising or new company formation, thus resulting in being able to both navigate conflict-of-interest issues and to successfully license start-ups.

- Facilitates the licensing of innovations to high-tech companies. Input from industry was utilized to create the Engineering Portfolio of Inventions for Commercialization (EPIC) programme for licensing.

- Assist other non-profit organizations with licensing by establishing a separate, wholly owned limited liability corporation (Stanford University OTL-LLC). Stanford University OTL-LLC was established to extend Stanford University's expertise to act as a licensing agent for non-profit organizations.

Stanford University's best practice programmes and processes have become an international innovative leader in technology transfer, which describes an ecosystem that encourages creativity and entrepreneurship. Eesley and Miller (2012: 12) reported that Stanford University's graduate school of business offers specialized expertise to companies with specific requirements on new technology. This allows the university an insight into industry challenges and consumer opportunities. Companies founded by Stanford University alumni include giants like Google, Hewlett-Packard and Cisco Systems, which form the backbone of Silicon Valley. Eesley and Miller (2012: 15) established that the university partners with industry and businesses to identify challenges that transform research into real-world applications. Industry often requires a low-risk environment such as a university laboratory for the testing of new ideas. Universities are found to be the ideal partners in the research testing by providing venues for testing ideas and engaging in high-risk research. Valuable lessons can be extracted from Stanford University's technology transfer process, which evidently has been adopted by universities globally.

Significantly, a successful entrepreneurial culture is also dependent on opportunities. Opportunities encapsulate the connection between entrepreneurial culture and entrepreneurship (Wong 2014: 41). In the university environment, many opportunities are created from continuous research work, which ultimately creates new opportunities.

Government grants are funding opportunities that also contribute to the enhancement of an entrepreneurial culture. The concepts of entrepreneurship can be difficult to understand, however the understanding stems from experience in specific environments. Having a developed entrepreneurial culture is therefore beneficial to the success of the institution. Since innovators play a significant role in the marketing and commercialization phase of an innovation, academic entrepreneurship and commercialization are important in the university context.

2.8.3 Entrepreneurship and commercialization

Innovation is often described as the lifeblood of organizations, and within a corporate setting the true value of innovation is manifested in outcomes such as the success of commercialization (Schendel and Hill 2007: 1). Commercializing involves the process of transforming theoretical knowledge that 'resides' at an academic institution into some kind of commercialized activity (Chilsea and Piccaluga 2010: 177). Commercialization ensures that the research can be used and explored by society through the implementation of innovations. Universities need to equip their staff and students with entrepreneurial skills in order to implement their innovations (Lakovleva 2011: 17). Entrepreneurialism at universities is epitomized by the rise in patenting, licensing and the creation of spin-off companies by academic researchers (Wright *et al.* 2007: 1).

University researchers and innovators play an important and decisive role in the commercialization of innovations. Their participation in the technology transfer process enhances their ability to identify the commercial potential of innovations (Owen-Smith and Powell 2004: 1698). For example, Chiesa and Frattini (2011: 258) argued that many innovations fail due to a poor understanding of the commercialization process. Innovators are important not only for the identification of innovations, but for the successful commercialization of such innovations since most innovation are sold at an embryonic stage and further development requires inventor participation (Thursby and Thursby 2003: 211). This view is supported by Spilling (2010:10), who argued that commercial activity relates to the key driving force, which is “the entrepreneur and their ability to identify and develop business opportunities”. Clark (2004: 66) also highlighted the entrepreneurial transformation of universities requiring collective entrepreneurial action. D’Estea *et al*. (2013: 6) strongly supported the view that prior experience in innovation-related activities matters for future academic entrepreneurship.

It can therefore be argued that academic researchers are more likely to contribute to and explore potential entrepreneurial opportunities in their personal research results. Innovators should therefore be more appropriately equipped with the background and in-depth knowledge of the innovation to better able to engage with the intricacies of exploitation of potential opportunities. While this is important, it must be noted that there is no clear understanding in management theory and practice that explains how commercialization decisions influence the market failure or success of new products (Chiesa and Frattini 2011: 2).

Legislative changes in most countries dictated the active involvement of universities in the commercialization of research results. Constraints on public expenditure exacerbated by falling enrolment figures and increased cost provided an incentive for universities to capitalize on new opportunities (Etzkowitz 1983: 1573; Chiesa and Piccaluga 2000: 2) and the need for commercialization and entrepreneurial skills. While universities have been encouraged to develop an entrepreneurial culture, Farsi, Modarresi and Zarea (2011: 2) indicated that many researchers believe that in essence, universities are not entrepreneurial organizations. Amongst some of the reasons offered were the dimensions and largeness of these organizations; hierarchal structures and organizational levels; intense monitoring of rules and processes; time constraints and the tendency to achieve results quickly; a lack of entrepreneurial skills; and inappropriate incentive methods and systems. Besides these barriers and constraints, many university professors and staff believe that being an entrepreneur prevents them from performing their main mission of learning and teaching (Zahra and Garvis 2000: 6). It must be therefore be noted that there is a concern that commercial activity takes one away from one's academic priorities. The National Research Council of the National Academies (2011: 1) contends that research shows little evidence that "commercially-oriented faculty are less likely to publish in the open literature…on the contrary, they are more prolific producers of scientific articles".

Market-related matters were amongst the major challenges facing entrepreneurship and commercialization (Tanev and Frederiksen 2014: 6; Chiesa and Frattini 2011: 9). Evidence suggests that despite the significant role innovators play in the commercialization of innovations, support structures within universities are vital in assisting the advance of technology into the marketplace. The dilemma and challenges related to the commercialization of university innovation are complex, and can only be reduced by appropriate support structures, strategic decision-making, experience in the field and concerted effort.

2.8.4 Benefits of academic entrepreneurship and research culture

Entrepreneurship and commercialization are activities not limited to identifying an innovation with commercial potential, but extend to all related activities associated with bringing an innovation to the marketplace (Mustar 1997: 41). Results from studies on technology transfer and commercialization revealed that academic entrepreneurship benefits rather than harms the academic enterprise. This is highlighted in the following examples:

- Normbie (2009: 16) found that inventors receiving Government funds had more peer-reviewed articles published, participated in more administrative activities in their faculties and their institutions as a whole, and were more commercially active than faculty members without such funding. Sponsorships and the receipt of funding seemed to positively impact on the confidence and entrepreneurial activity of researchers.

- Fini, Lacetera and Shane (2010: 1068) argued that professors who had started companies raised twice as much grant funding to support their academic research as professors, than individuals whom had not started a company. Industry partners are keen to fund researchers with evidence of previous experience, which plays a critical role in attracting funds.

- Sauermann and Cohen (2010: 97) established that life sciences and engineering professors who patented a lot did so because they wanted to change society. These findings are in keeping with innovation for public good, and the old traditional culture of researchers.

The perception of universities today is more than just being institutions of higher education and research. Globally the changing role of universities has been noted to be moving in the direction of entrepreneurial and technological innovation that positively affects economic growth. As supported by Meyer (2006: 7), universities are increasingly viewed as proactive contributors to technological development and economic growth. The past separation between pure research and applied R&D has given way to new forms of partnerships and collaborative association in the changing context of knowledge production (Bercovitz and Feldmann 2006 cited in Tantiyaswasdikul 2013: 479). The role of a university as key player in the knowledge-based solution supports its role of being identified as a large source of new innovation. This allows the university to grow as an entrepreneurial university by the commercialization of innovation and contributing to economic growth.

Emery (2014: 17) asserted that many researchers search beyond the tenure essentials (namely grants and papers) for commercial value, searching for something that is not easily achievable as written material. As indicated by Emery (2014: 17), generally "faculty want to make an impact, which is not quantified in tenure criteria, the self-fulfillment faculty member receives when research makes a difference and benefits society, is worth the extra effort". This type of effort benefits the university and innovator alike. Entrepreneurial activity will increase should the university encourage, nurture and support the activity. Third stream income generated on innovation with commercial value is a much-needed asset for higher education, more especially in the climate during reduced government subsidies.

Baxter (2011: 11) confirmed that universities such as Stanford, *Massachusetts Institute of Technology* and Wisconsin have proactively contributed to the evolution of a community-wide ecosystem supporting innovation. According to Emery (2014: 22) a true innovation community, or ecosystem, has minimal restrictions. Any restriction or stumbling blocks are therefore frowned upon and seen as counter-supportive to innovative potential and the ability to commercialize. Many university infrastructures do not embrace the global open unstructured model (Bradley, Hayter and Link 2013: 9). For a true innovation ecosystem to exist, the risk for a single institution to be committed to an innovation independently is too high. University commercial activity without external support will be minimal compared with the possibilities of team effort that includes higher education, industry and Government. Emery (2014: 21) suggested that to minimize risk, institutions should embrace innovation on a smaller scale, provide support services and resources to students and faculty who 'think outside of the box'. This allows the university an opportunity to make an impact outside the traditional roles of teaching, research and service. This type of activity may be seen as a creative research culture, rather than academic entrepreneurship.

It is frequently debated whether academic entrepreneurship is included in the nature and purpose of universities. It is further debated whether the university purpose should remain as education for education's sake, and whether research conducted for knowledge remains just for knowledge's sake. A response from Bok (2003: 162) indicated that "those who decry the rise of commercialization at universities, are misguided". This statement has been supported by Baxter (2011: 191), who submitted that university senior management should not be short sighted in that an academic researcher is employed for basic research and teaching only. Time and effort should be invested in commercial activity. Stronger emphasis on academic entrepreneurship encourages an increase in basic research, since academics face the pressure of linking their work to economic needs (Martin 2012: 546). As mentioned by Baxter (2011: 32), profits from commercial activity are generally reinvested into basic research. University management should therefore acknowledge the benefits of the commercialization of innovations by increasing their focus on academic entrepreneurship.

2.9 Conclusion

Effective implementation of IP legislation would automatically result in increased awareness on the commercial value of university innovation. This should effectively enhance the appropriate management of IP for the desired outcomes. Ultimately, IP emanating from public funds is monitored and regulated to the extent that it contributes to increased economic enrichment.

This chapter presented an overview of IP pertaining to higher education, public management and new public management. University ownership, obligations and challenges were evaluated. An understanding of the role of IP in higher education was described, which accounted for economic, political and social factors that set the stage for legislation, technology and competing interests. Factors contributing to IP policy and practice within higher education were discussed. The literature presented inter-related components to account for IP subject matter, the rationale for its protection and how universities are meant to manage innovation. The nature and impact of technological advancements of IP practice at universities were highlighted. The importance of academic entrepreneurship was also examined.

The next chapter presents an international perspective on innovation subject matter, protection and ownership determinations as applied by universities. Innovation experience, issues and debates around university commercialization will also be discussed.

Chapter 3
INTERNATIONAL PERSPECTIVES ON INNOVATION AT UNIVERSITIES

3.1 Introduction

The background to this study was analyzed and explained in the previous two chapters. In the current chapter, the researcher will review literature relating to international perspectives on the commercialization of university innovation. This chapter also analyses trends in research and development (R&D).

In the current market economy, innovation has proven to be a key ingredient for sustained economic growth. According to the World Intellectual Property Organization (WIPO) (2012: 6), studies in high-income countries have estimated that innovation accounts for as much as 80% of the economy-wide growth in productivity. Interaction with Government funded institutions helps industry to monitor scientific advances that are likely to transform technologies. This creates a two-way interaction between industry and publicly funded institutions, which enables joint problem-solving and encourages further novel avenues for research collaboration.

While teaching and research are the core traditional activities of universities, they also play a crucial role in national innovation systems. This contribution to society is through the transference of knowledge, while still building on their core activities. Its importance is distinctive in its own right, deserving of specific policies and resources to ensure effective functioning (European Association for Institutional Research 2014: 1).

Innovation activity is able to match society's expectations of innovative growth with full potential, without jeopardizing the main mission of education and basic research. The frontier of technological progress and the connection with fundamental research typically done in universities becomes crucial. Such innovations come from, or are closely linked, to fundamental research at universities. Productivity in the innovation process depends on the quality of education. In a study conducted by WIPO (2011: 14) it was noted that in middle-income countries, for example, the share of public research organizations in total basic research is close to 100% for China, 90% for Mexico and 80% for the Russian Federation. A substantial share of total research and development spending is accounted for by universities which perform the majority of the basic research in their respective countries.

3.2 Imperatives for intellectual property rights protection

Intellectual property rights, as identified by Hegel and quoted by Brooks (2012: 3), are important for creating personal self-assertion. It is contended that work is the personal expression of an author's or an inventor's thought. The inventor is entitled to control when and how his/her work may be utilized and/or performed in public, and has the right to avoid mutilations and changes. Manifestations of each creator's personality are there to be protected by intellectual property law, with a need to safeguard each creator's freedom of expression. The protection and enforcement of IP rights are important for creating strong reasons and incentives for innovation by safeguarding it from piracy, infringement, counterfeiting and other forms of IP theft. Professor William Fisher of Harvard University identified the following four analytical constructs of intellectual property, which support the imperatives to protect IP rights: utilitarian to capitalize on net value; Lockean (one has the right to the fruits of his/her intellectual labour); protection of personality in works; and fostering a just and an attractive culture. The aforementioned imperatives are discussed in the following sections.

3.2.1 Utilitarian theory

There is an epistemological tradition that the university should be a place devoted to enquiry and scholarship, free from utilitarian demands where the economic importance of higher education is acknowledged (Waghid 2008: 1). Wilkof (2014: 1) posited that the utilitarian theory applies economic constructs to propose how IPR's can achieve the ideal of "the greatest good for the greatest number". There is therefore a need to focus on balancing social costs and benefits associated with IP laws and rules. Moore (2012: 1068) believed that laws allow creators the means of control over their knowledge, as incentives. Unless this control is awarded, innovators lack the necessary incentive to create. From the moment new technology is valuable it has the potential to be copied or adapted by being imitated, thereby reducing the potential profit to the original inventor and potentially reducing or removing the incentive to engage in further innovative activities. The importance of IPR's encouraging innovation by granting successful innovators temporary monopoly power over their innovation is therefore critical (Breitwieser and Foster 2012: 3).

3.2.2 Lockean labour theory

The labour theory attempts to relate the rationale of John Locke concerning property rights. Locke stressed that a person has an expected right to the fruits of his labour in converting raw materials, facts and concepts that are 'held in common' into a product of enhanced value. The problem noted by Wilkof (2014: 2) in applying this theory is that according to the Lockean approach of intellectual property rights, ownership of innovation is difficult to clarify and additionally, the measurement of input and output is equally difficult to quantify. Intellectual property therefore becomes difficult to manage, resulting in uncertainty. According to Hughes (1998: 288) since the value of an idea originates from the mental labour of human persons, ideas are susceptible to Locke's theory linking property to the product of one's labour. He further suggested that propertisation of ideas expands the intellectual common by adding new ideas. It must be understood that because ideas are not perishable they are less subject to waste, and can be subjected to violation. In their analysis of the Lockean labour theory of property Bin, Lorenzon and Lucchi (2012: 21) contend that patents are an example of private appropriation that does not violate the Lockean 'enough and good theory'. This is supported by Bin, Lorenzon and Lucchi (2012: 22), who stated that patents do not disadvantage a situation as an innovation that has qualified for a patent registration would not exist.

3.2.3 Personality theory

According to Hegelian personality theories, our character traits, talents and feelings are owned by the individual (Moore 2012: 1066). As innovators expressed themselves by creating innovations, their personality traits become attached to their creations. Intellectual property ownership is one way to have control, which is subjected by personalities. The legal tradition identifies two features with strong ties to personality theories, which are the right to attribution of authorship and the right to control the integrity of one's work as protected by law. Similarly, the personality theory as described by Fisher (2010: 2) allows for "justifying property rights when it promotes human flourishing by protecting or fostering fundamental human needs or interests". Thus IPR's are important in two ways according to this view. First, by monitoring and controlling entities, both tangible and intangible, with a degree of control. Second, in some instances personality becomes fused with an object, thus moral claims to control feelings, traits and experiences may be expanded to intangible works. According to Moore (2012: 1066) while it is true, an argument is required to establish the moral claims. Personality-based theories have no evidence of a creator's personality with no moral foundation for legal systems of IP (Moore 2012: 1066).

3.2.4 Social planning theory

As highlighted by Wilkof (2014: 1), social planning theory diverges from the utilitarian theory in that it goes beyond the notion of 'social welfare' to a broader vision of society serviced by IPR's. Fisher (2010: 33) offered clarity on social culture from a consumer welfare point of view, in that one pursues a combination of IP rules that provide consumer rights by balancing creativity with incentives for dissemination. He also added that a rich artistic tradition offers a complex common language of culture, with opportunities afforded for creativity and subtlety in communication and thought (Fisher 2010: 33). If other intellectual works are held besides trade secrets, there must be a way of securing access for contracts such as non-disclosure agreements or non-competition arrangements. Society may purchase access by offering limited rights to authors and inventors. Moreover, if a particular society does not offer this sort of protection then innovators are likely to employ their talents in other areas, simply by moving to a society where such agreements are recognized (Moore 2012: 1068). Although there may be various non-Lockean methods of ensuring that the law rewards people for hard work, most countries have altered their policies to accommodate incentives for innovators.

In conclusion, all four theories are found to have considerable value. They identify non-obvious resolutions to specific problems. The personality and social-planning perspectives are easily understood from a practical perspective, which curtails a person's freedom on the basis of ideas of what is 'good for them'. In contrast, the utilitarian and labour approaches offer neutrality, objectivity and determinacy, although at times not for practical use. Fisher (2010: 36) stated that when courts are faced with problematic statutory interpretation, they often seek guidance from economic arguments and seldom from social-planning arguments. Each of the four theories must therefore be considered independently on its merits.

International perspectives on the intellectual property systems adopted by various countries are presented. The reason for the choice of countries is because of their dissimilar IP systems, policies and practices regarding ownership. The selection of countries offers a good combination of differing perspectives, thereby allowing for comparison. Contrasts are identified between the different country structures to assess best practices.

3.3 Intellectual property in America

During the 1970's and early 1980's, the USA experienced losses in its share of world trade as sizable trade surpluses turned to massive deficits. These challenges posed by Japan led to the American decline, which was attributed by the Japanese appropriation of American know-how (Drahos and Braithewaite 2004: 3). In this regard there was continual recognition of the importance of knowledge and innovation for the American economy, as well as foreign markets for products based on that knowledge and innovation.

Up until 1980, prior to the Bayh Dole Act, ownership of IP resulting from research funded by the American Government rested with the Government itself. As is the case at most universities globally, the majority of research funds for universities were subsidized by Governments. It was found that this type of ownership impacted negatively in creating value from technology developed at academic institutions. The findings were as a result of Government entities lacking the expertise and obligation to commercialize innovation.

Intellectual property challenges encountered globally regarding ownership of Government funded research was not unique to America. Countries around the world spent billions worth of funding each year on national public research, and encountered difficulties incorporating the research output for the benefit of society. Further, as a result of the

American Government not granting exclusive licenses on IP created, private investors becAME wary of the licensing and commercialization of innovation as competitors could gain access to the same innovation if desired. It was also realized that matters with a centrally managed system created difficulties as the policies were unclear (Baxter 2011: 6).

During 1980 the Bayh-Dole Act (PL 96-517, Patent and Trademark Act Amendments of 1980) created a patent policy among federal agencies funding research. This policy allowed universities to retain ownership of innovation created from federally funded research. Universities were obliged to file for patent protection and were required to ensure commercialization upon registration and licensing. The royalty distribution generated from research outputs are distributed between the innovator, the university, and the innovator's faculty, with the remaining amount utilized to support the process of commercialization. Prior to the Bayh-Dole Act, three significant barriers were identified as reasons for innovation created from Government funded research not being successfully commercialized (Christie *et al*. 2012: 77):

- There was an absence of commitment by Government sectors to commercialize IP. This lack of obligation was due to factors such as the absence of guidelines addressing the allocation of IP rights, and the lack of a comprehensive IP policy clarifying arrangements regarding commitment to commercialization.

- There was a deficiency of management support structures. Management infrastructure with precise commercial management expertise required to facilitate the commercialization of IP was absent. Researchers most often do not have such expertise and require access to people with the relevant skills and experience. Academics normally lacked expertise regarding the valuation and management of innovation, and therefore required support structures which were generally not in place.

- There was a deficiency of uniform licensing powers. Many Government funding agencies each had a different policy on licensing, thereby creating barriers. Government funding agencies with expertise on commercialization were often found not to be in the best position to do so. Universities were reluctant to invest in commercialization, as there was no assurance of ownership.

3.3.1 Enactment of the Bayh-Dole Act

The enactment of the Bayh-Dole Act in America allowed funded institutions such as universities to retain intellectual property rights for innovation stemming from funded research. Accessibility to innovation and discoveries from Government funded projects became easily available to companies. The Bayh-Dole Act is known to have enhanced innovation growth in America and allowed the Government to capitalize on technology through commercialization (Kim 2010: 180).

According to Senator Bayh (2006: 215), a co-founder of the Bayh-Dole Act, America began to lose its technological advantage in the 1970’s. Bayh (2006: 215) reported that the disturbing economic signs showed that the USA was losing its technological edge. Sanberg, Gharib, Harker, Kaler, Marchase, Sands, Arshadi, and Sarkar (2014: 6543) indicated that that Howard Bremer contributed to Senator Bayh’s report by stating that while the USA government had approximately 28 000 patents, fewer than 4% were licensed to industry. It was a waste of research investment that new ideas were not being utilized to the benefit of the taxpayer. He further stated that American productivity over the previous ten years had been dormant and not in keeping with free world competitors. Baxter (2011: 5) reported that small businesses which had compiled impressive records in technological innovation, had created new jobs but were receiving a small percentage of Government research and development fund. Loise (2012: 190) confirmed that the number of patentable innovations generated from government funds had steadily declined.

Senator Bob Dole from Kansas teamed up with Senator Bayh, and agreed that the USA could not meet the expense of billions of dollars expenditure on university research without a return on investment. Together they produced the legislation that research institutions would retain ownership of IP developed through Government funded research, with an obligation of commercialization. Such patented ideas could be licensed to industry for commercialization, thereby generating an income. University inventors would also receive a share of the royalties for the development of patents that were commercialized.

The Bayh-Dole Act was announced in the USA to address the challenges of valuable innovations which were discovered by universities utilizing public funds, but were not being commercialized. Baxter (2011: 32) suggested that this problem was due firstly to the absence of a uniform policy governing the ownership of such innovations; and secondly, to the lack of incentives for institutions to actively pursue commercialization with no guarantee of obtaining exclusive rights to the technology. It was further found that funding agencies did not have the necessary knowledge, experience or capacity to realize the commercial potential in new innovations. Christie *et al*. (2012: 41) reported that this resulted in the USA's decrease in competitiveness in comparison with other industrialized countries; therefore, innovations had to be prevented from being lost to overseas markets. The goal of the Bayh-Dole Act was to deliver a uniform system that managed IP rights at publicly funded research institutions. Ownership of innovations created using public funds were vested in the universities. Established administrative structures to support the obligation to commercialize innovations were set-up at universities. Royalties generated from commercialization were required to be distributed between the university and the inventor to provide an incentive for the creation of innovation for practical use. Furthermore, Bradley (2009: 18) advised that the legislation regulated additional incentives regarding patents by introducing the possibility of the Government confiscating ownership of an innovation should it not be patented and commercialized within certain time frames. The Government was therefore afforded ‘march-in rights’ to be exercised in the best interest of USA citizens.

3.3.2 University ownership of innovation

Innovators, staff and students of the university may be able to claim ownership depending on each individual circumstance. Claims of ownership are subject to the decision to commercialize the innovation of concern. According to Christie *et al*. (2012: 29) proprietorship of innovation in the university context concerns four main factors:

- Under USA common law, the innovator owns the rights in the innovation created by him/herself, irrespective of that innovation being created in the course of employment. There are two exceptions to this rule: firstly, when an individual elects to assign to the employer an innovation created by themselves with an agreement. Normally, this will occur under an agreement between the employer and employee. Secondly, the exception of the person being employed specifically to invent.

- University IP policies that adopt the general principles that permit the university to make wider proprietorship entitlements.

- Peripheral agreements with private enterprises that provide funds for specific projects.

- Application of the Bayh-Dole Act of 1980 which controls ownership of innovations produced pursuant to fund agreements between universities and Government agencies.

The proprietorship of innovations generated from publicly funded research at universities in the USA is governed by a complicated framework with themes. These include, amongst others, the obligation to commercialize under the Bayh-Dole Act and provisions that give preference to American industry and small businesses throughout the commercialization process. Further themes include royalty distribution between the inventor and their employer (be it the Government, university or other institutions) to provide an incentive for the creation of innovations with practical use; and the retention of a non-exclusive, royalty-free license by the Government in most innovations created using public funds (Zuniga 2011: 3).

3.3.3 Commercialization of innovations

As previously stated, prior to 1980 there was an absence of a uniform policy governing the proprietorship of innovations generated by universities in the USA with public funding. Each funding agency had developed its own rules. In practice, however, funding agencies retained ownership of innovations created with public funds. There was therefore a reluctance to grant universities exclusive rights over those innovations that the Government owned. Innovation derived from research conducted from funded research was owned by the funding agency. Baxter (2011: 31) posited that this resulted in a trend that Government retained ownership of 80% of the approximately 53,000 innovations produced with public funds over a period of time. Of the innovations owned by the Government, however, only 10% were licensed and 5% were put to commercial use. A large number of potentially valuable innovations were being lost, with no return on investment from publicly funded research. The USA was seen as suffering from an innovation lag. Christie *et al*. (2012: 47) declared that new innovations with the potential to commercialize were lost to international market developers as a result of the local regulatory environment.

The Bayh-Dole Act has been widely acknowledged as the catalyst for transformation involving the goals of universities. This Act allowed universities to retain title to funded innovations, thereby encouraging universities to license innovations to industry in return for revenue from patent licensing. The ownership of intellectual property (including patent, copyright and others) provided motivation, especially economic incentives, for a university to promote and emphasize technology transfer activities. It allowed universities ownership on innovations created using public funds, regardless of the funding agency. This removed the Government from the commercialization process, which incentivized universities to commercialize by positioning innovations for practical use. More than 250 American universities established technology transfer offices (TTO's) to cope with the increase in technology transfer activities since implementation of the Act (Rush 2011: 133). The outcome of this led to TTO's performing an increasingly direct and indirect decisive role in the changing aspects of innovation and industrial growth. As posited by Abramo and Pugini (2012: 52), this initially started in the USA and filtered into Canada, the United Kingdom, and then to other European Union and Organization for Economic Co-operation and Development (OECD) countries. According to studies conducted by the Association of University Technology Managers (AUTM) (Association of University Technology Managers 2012: 4), and Tseng and Raudensky (2013: 2), patent registration to American universities grew from less than 250 in 1980 to 4 700 in 2011, an almost twenty-fold growth.

Clark (2006: 183) commented on the merits of the Bayh-Dole Act in encouraging commercialization by stating that, "as part of the mental process which leads to an innovation, the inventor often envisions possibilities for application which are not immediately evident to others. The inventor's personal persistence and confidence is often the deciding factor which ensures the innovation is prevented from being set aside or ignored". This type of situation experienced by many innovators was addressed and accommodated by the Bayh-Dole Act. In the past, innovators depended solely on the institution to take forth the product for the benefit of society. With the emergence of the Bayh-Dole Act, inventors had incentives to commercialize.

The need for reliable technology transfer mechanisms to encourage the commercialization of innovation was a much needed process for success. It was difficult for Governments to transfer innovation for which it had ownership. By 1980 the government had accumulated about 30,000 patents, of which only 5% led to improved products (Council on Governmental Relations 1996: 1). It was found that registered patents were not being utilized, as government did not have the expertise to develop the innovations. Thus the Bayh-Dole Act allowed universities ownership over patented innovations, with a positive impact that included the following (Vivekanandan 2008: 483):

- Universities increased commercialization activity by developing new businesses, and creating industries that expanded new markets.
- University/industry collaboration assisted in moving university research to the marketplace more efficiently than previously, while ensuring benefits to the public.
- Ensuring that the commercialization process of federally funded innovation was developed at a rapid pace for significant impact on American industrial growth.

It is important to consider both sides of any Act to assess the rate of success. Literature identified and attributed negative consequences resulting from the Bayh-Dole Act; amongst the most serious is contained in the discussion that follows:

- **Bayh-Dole Act changed the nature of academia –** Traditionally, basic research was viewed as a mere curiosity or indulgence. Literature dictates that commercial orientation from research creates a focus towards outcomes by attaching monetary incentives to a discovery, which sometimes leads to research bias. Ultimately the commercialization of patents runs counter to the public service role of universities. University licensing practices led to patent hold-ups, such as a patent-holder impeding product development by demands for royalties. Although the purpose of patents is to allow the owner monopoly rights to impede others' use of the innovation, this result seems questionable when taxpayers funded the innovation and universities are left with the monopoly. Further concerns about a conflict of interests was reported between industry and research universities (Levenson 2005: 7). According to Rhines (2005: 3) Mildred Cho, a senior researcher at Stanford University, reported that "the Bayh-Dole Act created opportunities for conflict of interest for university faculty members, as academic-industry partnerships can offer direct financial rewards to individual faculty members, in the form of consulting fees, royalties and equity in companies while simultaneously funding faculty members' research". He also added that this may lead to researchers being biased to companies when licensing patents, which would not promote fair competition. Further, it may also lead to skewed research, which was another reason for concern. The transformation culture on knowledge spillovers is potentially more serious than acknowledged. It would therefore be of interest to investigate the impact of expected effects and concerns.

- **Shift of focus of research away from ground breaking, fundamental research to applied research -** Literature revealed that the Bayh-Dole Act formed incentives for universities to shift from basic research which produced less patents, to applied research that generated an income. Baxter (2011: 34) confirmed that university research culture is found be 'skewed' towards applied research. An example of this occurs when an innovation has been integrated into the economy from enhanced research on existing products to increase productivity and quality (Schacht 2012: 13). Other observers have expressed concerns that incentives provided by the Bayh-Dole Act may have encouraged the shift of research towards 'applied' work and away from basic research, which may have negative long-term effects (Dasgupta and David 1994: 490). Levenson (2005: 7) advised that on the contrary, the results of a study on 3 400 faculties at major research universities proved that the ratio of applied research to basic research had not changed.

- **Double taxation -** Double taxation occurs when the Government incurs expenses to develop an innovation, and then spends additional tax funds in the form of royalties to use the innovation in subsequent funded research. By transferring the ownership rights of federally funded innovations, owners are given unprecedented rights to intellectual property that was cultivated with public money (Yeh 2012: 17). Shifting ownership rights for federally funded innovations from public agencies to the private sector affects what the taxpaying public receives in return for its investment. Sweeney (2012: 11) therefore suggested that this partly explained the reason why the taxpaying public is not receiving sufficient returns on their investment from basic research, and are further double-taxed. This is argued by USA Senator Russell, who raised the following: "Is there any limitation on this proposal as to how much one could charge the public to have the benefit of what the public had already paid for, as the initial research was funded from research funds that is derived from taxpayers' money?". This is reinforced by Baxter (2011: 27), who argued that "the public was being forced to pay twice: once through the taxes that funded the innovation and secondly, through the cost of the monopoly given to the institution over the new technology".

- **Instilling a culture of secrecy at universities -** The Bayh-Dole Act enhances research secrecy and stifles scientific progress by restricting the free flow of information (Rhines 2005: 3). By encouraging the registration of IPR, it does not offer an incentive to engage in research but merely generates incentives for academics to commercialize their discoveries. Yeh (2012: 4) explained that as regulated by the Bayh-Dole Act, in the technology transfer context anticommons occurs when too many patent rights are awarded in certain fields to universities and non-Governmental entities. This interferes with the progress of research in the respective fields. Innovations are monopolized, and the under-utilization of discoveries occurs. With the enactment of the Bayh-Dole Act, *innovations* are *monopolized* in *private hands rather than disregarded* by *public agencies (Sweeney 2012: 9)*.

Intellectual property specialist Mark Lemley commented that "while in theory patents spur innovation, they can also interfere with it. Broad patents granted to initial inventors can lock up or retard improvements needed to take a new field from interesting lab results to commercial viability" (Levenson 2005: 6). Researchers generally shared and passed over research results for follow-on research. Now restrictions are emplaced and results are not shared for follow-on research (Yeh 2012: 14). Innovations over patented technologies are therefore known as 'patent thickets'. Although the Act provides incentives for innovation development, some innovations would have been developed without the incentives of the Bayh-Dole Act and are now less available because of it. Sweeney (2012: 12) emphasized that patenting and commercialization inhibit tacit knowledge spillovers between universities and industry. This allows the culture of the "private world of patents to dominate the open public world of science" (Schacht 2012: 9). As a result, conferences, informal networking and even publications become more guarded and delayed.

- **Cost and quality of research -** As suggested by Sweeney (2012: 9), the Bayh-Dole Act may have had an unintended consequence on the Property Rights Act. University ownership of IP can indirectly decrease the incentive for the private sector to pursue collaborative ventures. Yeh (2012: 13) suggested that the results of a greater cost and the trouble associated with negotiating intellectual property rights between parties lowers the incentive for collaboration. The possibility of a lesser incentive for collaboration can result in reduced collaboration, which in turn results in research of an inferior quality than previously (Bradley 2009: 17). The high expense of patent management versus net revenues earned by USA universities should encourage universities to be more realistic regarding economic returns from patenting and licensing activities (Sweeney 2012: 14). Due to this high cost, not many universities make substantial profits from their tech-transfer offices. This may be indicative of universities over-patenting, spending significant time and resources managing patents that do not generate enough revenue to cover their overheads. Schacht (2012: 16) hypothesized that the long- term effects of the Bayh-Dole Act may negatively affect the quality of research. Gorsa (2012: 5) suggested that the Bayh-Dole Act may have endangered the quality of research, and the forceful culture towards IP rights may possibly decrease the incentive of the private sector in seeking collaborative ventures with universities. McKay (2011: 11) commented that an inadvertent effect of the Bayh-Dole Act was that it reduced the quality of research and lowered the calibre of innovations in the American economy. The growth in commercialization may therefore be lacking in a substantial effect on the American standard of living. This was supported by Henderson (2002: 199), who conceded that the calibre of patents continued to rise throughout the 1980's. There is inadequate empirical evidence, however, that the Bayh-Dole Act has reduced the quality of university research, although it is clearly evident that the function and resolution of the Bayh-Dole Act was well intended.

- **Lack of protection for the public good -** As reported by Sweeney (2012: 188), the resolution of the Bayh-Dole Act has affected research practice and the norms of science. This has precipitated 'anticommons' problems which contribute to patent hold-ups that in turn lead to increased consumer prices. Under the theory of anticommons, it is noted that it results in IP being underused if too many people have the right to exclude others from using it, thereby interfering with the progress of research. Innovations that could be of use to taxpayers, such as green technologies, are often owned by private investors and are developed and sold at a higher cost than it might have been as a result of the Bayh-Dole Act. University academics did not traditionally consider research-related IP as an opportunity for economic enrichment. An example of research for the public good is the case of the polio vaccine. The polio vaccine was discovered in 1954, an innovation worth millions, however the inventor refused to register a patent. The inventor believed that no individual should own or profit from discoveries made about the natural world. A second case of research for the public good was the discovery of the gene-splicing technique in 1973. The inventors resisted patenting as they acknowledged that their discovery depended upon contributions of earlier scientists' results that were freely available. Thus, traditional academics were of the view that knowledge should be placed in the public domain without proprietary restrictions, which limits access.

3.3.4 Perspectives on ownership rights

The focus on IPR within universities has reduced the motivation for the private sector to pursue collaborative ventures. A study conducted by Hall, Link and Scott (2011: 17) found that one-third of respondents in an advanced technology programme believed that IPR concerns were the main impediment to collaborative university-industry research. Hall, Link and Scott (2011: 18) further elaborated that difficulties arose once universities were allowed to own the IP produced under sponsored research. Industry believed that if universities want a part in the ownership of rights, the university ought to take an equity position in the venture.

Additionally, a few firms reported that universities had an inflated vision regarding the value of their IP. These views were more pronounced with companies that were undertaking short duration projects, and which had previous experience of collaborative ventures with universities. Hall's (2014: 11) study revealed that obstacles which prevent the sought-after research partnership have a greater chance of occurring when the research is expected to lead to less appropriable results, which have a relatively greater degree of 'publicness' and the expected duration of the research is relatively short-term. Furthermore, prospects are higher when the industry partner has prior involvement partnering with a university, and is conscious of matters that may be encountered. Universities have the view that with the brainpower and equipment used to develop a new technology, they should benefit financially as would an industrial partner. This perspective is further supported by Link (1999: 293), who stated that a common complaint amongst industry is that there is often a tendency for the university to be overly optimistic about the commercial significance of an innovation.

The overall benefits formed by the Bayh-Dole Act critically outweigh possible adverse consequences. It must be noted, however, that the Act further accommodates incentives for all concerned and introduced compliance measures to confirm that innovations are effectively maintained. Ultimately, the Bayh-Dole Act gave universities the opportunity to take ownership of innovations and to remove the Government from the process of commercialization. Finally, and by no means the least, it provided an incentive for commercialization to occur. Its strengths should evidently be capitalized upon.

3.4 Intellectual property in Japan

At the time of changes to the system that resembled the Bayh-Dole Act, many Japanese universities were not yet the major management body of their IP. The management of IP in Japan had traditionally been the task of the national and local Government. Japanese universities were known to have had limited experience in handling such tasks. National universities in Japan were formerly part of the Government, and university staff were recognized as civil servants. According to Chen (2011: 5) this made universities bureaucratic, unresponsive to changing demands, and unable to effectively engage with society and the private industry sector. In early 2000 government policymakers acknowledged the importance that innovation could play in assisting Japan to recover from two decades of economic depression. As posited by Kagami (2015: 96), national universities were best placed in addressing the entrepreneurial gap and in fostering technology commercialization for innovation through university start-ups. In 2004 universities were made independent from the national government. In an attempt to re-start the economy, universities were identified as drivers of innovation. Universities were then given the mandate to disseminate and utilize their research for the benefit of society (Kagami 2015: 97).

As stated by the World Intellectual Property Office (WIPO), the IP system of Japan is a highly developed system. It is a known fact that most of the patents granted globally originate from Japanese citizens. This has contributed to the strongest global rate of IP growth in nearly two decades. According to the World Intellectual Property Indicator (Taplin and Nowak 2010: 1), during 2013 Japan was globally ranked second for the highest number of patent filing applications. Although as reported in a recent study by a German institute, the Japanese language has the most problems with incorrect translations, which results in a high rate of errors in intellectual property translations on patent specifications. This compromises the nature of patents. A further challenge experienced in Japan is that a Japanese patent requirement is a complete translation into Japanese characters.

Jiao (2011: 74) indicated that since the corporatization of national universities they were forced to manage the IP belonging to them. As Watanabe (2010: 205) explained, in line with the Act (similar to the Bayh-Dole Act) Japanese universities set up innovation committees to take decisions on IP disclosures. They were mandated and considered to be ethical and appropriate to go through the selection committee to ascertain the extent and value of innovation, prior to patent application. As a result of the implementation of the 'Japanese version' of the Bayh-Dole Act, universities received approximately 10 000 cases of innovation disclosures per year; filed approximately 7 000 patents; and successfully commercialized more than 5 000 cases of technology transfer contracts.

Good and bad aspects were presented through the introduction of the similar Bayh-Dole Act in Japan, which produced desirable and undesirable outcomes (Watanabe 2010: 201). It was not possible to achieve identical outcomes even if the systems were similar, as a result of the following factors:

- Factors such as the differences in the climate of faculty; the character style of researchers; corporate technological structures; business practices and including systems were factors that separated the USA and Japan in commercialization efforts. For example, the legal system was not permanent and according to Chen (2011: 3) it was recommended that it should be amended in accordance with the environmental and societal needs of the Japanese people.

- Traditionally, the management of IP in Japan had been a task for corporations. Most research universities in Japan are national universities which traditionally have very limited experience handing tasks such as IP management. The university technology transfer staff were not recognized as professionals. The differences in research cultures and the mentality of researchers within various ethnic groups were also noted. Entrepreneurship was not as emphasized in Japan as compared with the USA. Structures and processes within large firms were too complex and were not conducive for collaboration with universities.

- As reported by Das (2012: 57), conflict in relationships had developed between the university TLO's and individual faculties within the university. As some TLO and university IP headquarters had a conflictual relationship this affected the overall performance, which decreased successful outcomes. Similar issues of a conflict of interests were acknowledged and occurred in other countries, including the USA. This was considered a fundamental systemic problem common to countries with Acts similar to the Bayh-Dole Act.

The overall experience of the Japanese version of the Bayh-Dole Act revealed that the numbers of innovation disclosures and patent applications, together with commercialization cases, grew rapidly. This was identified as a definite strength in the new system. In this regard, Kagami (2015: 110) reported that the Japanese royalty distribution policy for commercialized innovations has changed to the inventor (researcher), the department the inventor belonged to, and the university headquarters, with a ratio of 40%, 30%, and 30% respectively. This new rule is believed to be the equivalent of the leading universities in the USA, including Stanford University and the Massachusetts Institute of Technology (MIT). The establishment of TLO's was found as a significant improvement. The new IP system tended to positively impact on small- to medium-size enterprises, but resulted in a negative effect on large firms. During 2010 Japan therefore made further amendments to their Act, which included the introduction of a new requirement to obtain approval from national Government when transferring IP rights to third parties, thereby correcting restrictions and situations of uncertainly. The Japanese IP system, similar to the Bayh-Dole Act, was built on balancing accountability to taxpayers and incentives to universities to utilize research results. Watanabe (2010:

216) argued that the laws should be amended to accommodate environmental changes and societal needs accordingly. Specific measures for university entrepreneurship were to be included in a new policy of the Government of Japan, namely the Industrial Competitiveness Enhancement Act.

On 4 December 2013 the Industrial Competitiveness Enhancement Act came into effect with the Japan Revitalization Strategy. Due to the National University Corporation Law enacted in 2003, and before the enactment of the Industrial Competitiveness Enhancement Act, Japanese national universities were not legally allowed to own any particular enterprise, including their university start-ups (Watanabe 2010: 211).

3.4.1 University - industry collaboration

State-owned universities in Japan had previously been protected from the pressures of the private sector. They therefore showed little interest in collaborating with industry. Universities were reported as having strong anti-business emotion, believing that large businesses were responsible for moving Japan into the painful 1945 Pacific War (Chen 2011: 11). It was therefore uncommon for State-owned universities to offer technical services to industry. Only as recently as the 1990's did Japanese society positively alter collaboration between university and industry. The loss of competitiveness by Japanese firms to the USA was a direct cause of the change. Industry began to display an interest in utilizing the knowledge from universities' research results, instead of undertaking independent research. The utilization of advanced knowledge produced by universities became a matter of urgency in Japan.

Japanese businesses found the universities to be unresponsive to the requests of business, and to be slow and inexperienced in managing IPR's. While the current progress is encouraging, collaboration between universities and industry is cordial and has strengthened since 1990. Many Japanese universities have reviewed their policies to find the right balance.

As outlined by Kagami (2015: 103), if universities are to be drivers of innovation, then the following imperatives need to be considered:

- National universities should disseminate and utilize their research results for society by contributing to its development, including innovation. This is clearly stipulated in the National University Corporation Law.

- National universities must gain more external funding to maintain the level of quality and quantity of their research and education. Soon after the incorporation of national universities, the Government began to decrease its budget allocation to each national university by 1% per annum. In 2012 these funds comprised only 36% of the university's budget. As an example, this equated to a deduction of US$10 million a year from the annual revenue of the University of Tokyo. The university previously depended on the Government subsidy for approximately 60% of its annual budget.

- Japanese universities need to be proactive, creative and highly motivated for innovation commercialization to result in success for society and to make a global impact. After the incorporation of national universities in 2004, IP derived from university research activity that resulted in patents became an asset of high focus in Japan.

3.4.2 Encouraging entrepreneurship

Researchers argue that the lack of entrepreneurship during the past decades in Japan could be the reason for Japan's economic depression. Since entrepreneurship is the source of growth in the modern market economy, the relative lack of entrepreneurship in

Japan added to the nation's economic malaise over the past two decades (Kagami 2015: 110). It has been suggested that to assist Japan in revitalizing the economy, incentives must be created to promote start-ups and to rapidly commercialize cutting-edge technology (Bank of Japan 2013: 3).

Fukao and Kwon (2011: 3) attested that Japan's entrepreneurship gap can be attributed to various factors including cultural, societal, educational, legal and financial, as discussed below:

- **Culture -** Kagami (2015: 114) stated that the impact of culture should not be underestimated. Japanese culture does not encourage risk-taking behaviour, unlike the American culture that embraces individualistic behaviour. The Japanese culture emphasizes conventionality and consistency and is, therefore, relatively risk averse. The anxiety of failure that results in social alienation poses a huge psychological barrier for entrepreneurship. As Luoma, Paasi, and Nordlund (2008: 1) argued, the commercialization of innovation is comprised of various uncertainties, mainly if one aims to deliver a product, process or service with unprecedented performance features. The commercialization of innovation accordingly includes many risks, which the Japanese culture would find difficult to confront.

- **Social status -** It is felt that the social status of entrepreneurs in Japan is not as high as expected. Japanese society is significantly group-oriented by comparison with societies in the West. Japanese parents do not typically support their children's aspirations for becoming entrepreneurs. Thus as Kagami (2015: 110) presented, researchers have argued that the lack of entrepreneurship during the past decades in Japan could be one of the major reasons for Japan's economic depression. Through the evolution of the innovation ecosystem, the University of Tokyo is moving toward its goal of contributing more to the world through innovation based on university entrepreneurship. As Jiachuan (2010: 1) explained, while political conditions for entrepreneurship are on the increase, a solution for entrepreneurship in Japan would be to address the social factors that hinder entrepreneurship among the youth.

- **Educational system -** Japan's education system played a central part in recovery and rapid economic growth in the decades following the end of World War II. From the earliest age, Japanese children are indoctrinated in Government-run schools to work within a group. Individuality is sacrificed for the achievement of this goal and the most important objective is consensus. This 'group thinking' method is continued throughout the education of children until they graduate from high school. Despite the numerous educational changes that have occurred in Japan since 1868, and again in 1945, the education system still reflects long-standing cultural and philosophical ideas. In spite of the success of the education system since World War II, problems remained through the 1980's. There was a concern that Japanese education should be responsive to the new requirements created by international challenges of the changing world of the twenty-first century. Jiachuan (2010: 1) believed that the true reason for the stagnant entrepreneurial activity in Japan lies in the education system and the youth, who either conform or retreat from entrepreneurship. The traditional employment model still maintains a hold over many desired career paths, and many still regard entrepreneurship as a risky and potentially dangerous path. Young people in Japan therefore find themselves at a crossroads, wondering whether old institutions and methods will prepare them for the new challenges. These barriers are therefore the reasons why entrepreneurship skills are lacking in Japan.

- **Legal framework -** The Japanese legal framework needs to be adjusted and aligned to the changing world. The promotion of domestic entrepreneurship concerning the bankruptcy law needs to be addressed. If a start-up fails in Japan then the founder's guarantor or family adopts responsibility for the unpaid debt

  (Bank of Japan 2013: 6). Kagami (2015: 112) advised that the family remains liable should the founder member die. The law of partial liability is not as clearly delineated as in other countries, which is a primary factor blocking would-be entrepreneurs in Japan.

- **Capital -** Raising capital is one of the most challenging tasks for start-ups. This is supported by Kagami (2015: 113), who stated that the capitalization of start-ups in Japan is not as easy as it should be. Risk money that is available for entrepreneurs in Japan is quite limited. Most Japanese local venture capitalists are spin-offs from Japanese banks or security firms, which are generally conservative, domestic-oriented and unprofessional. They are often not administered by professionals with operational experience running start-ups, and they tend to take decisions that are as risk-averse as possible. Kagami (2015: 113) further stated that banks are reluctant to lend funds to entrepreneurs, with lending practices that impose punitive conditions on start-ups. Demands such as full collateralization of all the assets is a requirement of the Japanese Banks.

Traditional venture capitalists have been joined by many new players since 2000, including individual private investors, accelerator funding, and corporate venture funds. Kagami (2015: 115) advised that government can play a useful role in encouraging venture financing through several means, which he explained as follows:

- Setting up of tax incentives for investors. According to the Nikkei Asian Review (2014: 1) the Japanese Government is weighing greater tax incentives for investment in venture-stage companies, which could speed up the country's entrepreneurial metabolism.

- Loosening of regulations that discourage university endowments or large pension funds from investments. An idea to assist entrepreneurship is to increase the income tax deduction for so-called angel investors that provide fledgling businesses with the required funds.

- Establishing funding mechanisms at Japanese universities to bridge the gap between research and commercial application (gap funding). To nurture entrepreneurs directly, the Government can offer income support to assist with living expenses.

- Creating programmes focused on the development and commercialization of innovation that stimulates small businesses to participate. There is now a growing tradition of innovation that builds bridges between academia and industry. As part of the new Government initiatives, young entrepreneurs and innovators from Japan were invited to attend the G8 Innovation conference in London. On their return, Mirai (2012: 11) reported they had made it their mission as venture capitalists to find ‘raw’ disruptive technologies and to prepare them for global commercialization.

- Establishing Government-backed venture funds to encourage the Innovation Network Corporation of Japan in accelerating venture businesses with special provisions to allow national universities to invest in ventures. The State-backed New Energy and Industrial Technology Development Organization selects ten to fifteen groups a year to receive an annual five million yen in income per person, and fifteen million yen in running expenses per group for up to two years.

As part of the Division of University Corporate Relations, the innovation and entrepreneurship office was founded in 2004 to promote entrepreneurship at universities. The office has evolved its functions over the past ten years.

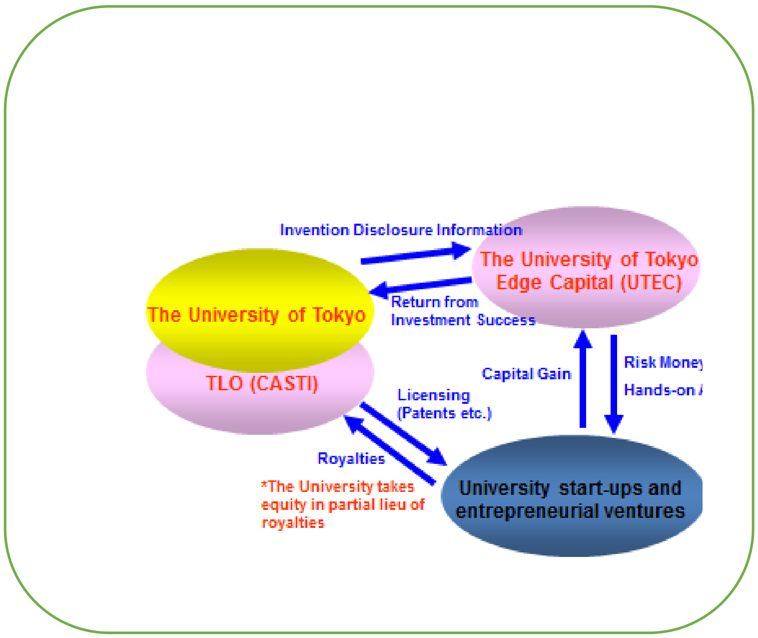

Figure 3.1 University Entrepreneurship Ecosystem (adapted from Kagami 2015).

The central office for entrepreneurship and innovation provides effective support for university entrepreneurship. As illustrated in Figure 3.1, this includes: i) services for entrepreneurship education, consulting and mentoring, and venture incubation; ii) technology licensing organization (TLO) dedicated to the university; and iii) a venture capital arm dedicated to the university. According to Mirai (2012: 4), based at the University of Tokyo is the only wholly owned technology transfer subsidiary of the university. It acts as a bridge to pass technologies developed at the university to industry, offering a one-stop service providing access to IP belonging to the university. This office employs more than 20 professional staff (Kagami 2015: 105).

The literature reveals that the number of staff employed at TTO's does not determine the success of the commercialization of university innovation. Having a large number of registered patents does not always turn them into licenses. Sometimes with just a few registered patents, one or more may turn into significant earners. The focus of an IP&TTO should not only be on generating a profit; a profit focus may likely lead to encouraging unrealistic negotiating terms. The focus should still be on market-driven criteria such as spinout profitability and product sales. Such measurement is likely to encourage universities to focus their energies on innovations with the greatest potential. University IP&TTO's should engage the expertise of venture capitalists, business angels, industrialists and other expert professionals to identify the technologies with the highest commercial potential. Although the challenges of university technology transfer are arguably greater than commercialization in the private sector, the principles of success remain the same.

3.5 Intellectual property in Australia

The 'public sector' in the context of Australian research and development covers research undertaken in the university system as well as research by Government-owned research agencies, such as the Commonwealth Scientific and Industrial Research Organization (CSIRO). As Walker (2010: 252) expressed, the Australian government also supports public sector research and development through direct financial support to Co-operative

Research Centres (CRC's) and through Government-owned Research and Development Corporations. The CRC programmes are comprised of Government approved and funded research collaborations between universities, industry and the CSIRO.

Intellectual property management in Australia is guided by the Patents *Act 1952* (*Cth*) and the Patents Amendment Act 2000 (Cth) from 24 May 2001. These Acts are revised by practices at research institutions, IP policies, third party agreements, and the National Principles and Interim Guidelines which govern research undertaken with funding from the Australian Research Council (ARC) and the National Health and Medical Research Council (NHMRC). The intellectual property principle of common law regulates that an employer is entitled to IP rights generated by an employee in the course of employment.

Universities have the right to claim ownership of innovations produced by academic staff in the course of their employment, both in common law and under the university IP policies and statutes.

3.5.1 Ownership claims

The Australian general principles of patent ownership are illustrated in Figure 3.2. Patent ownership is the culmination of a three-step process.

Creation of Innovation

↓

Step 1: Entitlement to Apply for Patent.

↓

Step 2: Application and Entitlement to Grant.

↓

Step 3: Grant and Ownership of Patent.

Figure 3.2 Australian patent ownership process (adapted from the Legal Framework for Patent Ownership in Publicly Funded Research Institutions 2012).

According to the Patents Act 2000 (Cth), a patent will only be granted to the person who owns the innovation. The Patents Act has two exceptions to this rule: the first exception occurs when the inventor voluntarily assigns ownership of the innovation to another person, for example to further develop and bear the costs of commercialization (Christie *et al*. 2012: 22). The second exception is by law that affords ownership to a third party. Ownership of innovations generated at universities may be claimed by academics, students, the university itself, and third parties involved in providing funds or expertise (McKay 2011: 1). Ownership claims depend on the following (Christie *et al.* 2012: 23):

- Once an innovation is conceived, the inventor is entitled to legal rights over the innovation.

- University-enacted statutes and policies that modify the common law notion of employment to claim ownership of staff or student IP.

- External agreements with public and private bodies providing funds for specific projects.

- Ownership affected by the claimant deciding whether or not to commercialize.

McKay (2011: 7) recommended that it would therefore be necessary to separately consider the provisions of statutes, policies, and agreements which dictate the distribution of ownership rights with third parties, if an innovation is or is not to be commercialized.

Universities rely on common law to claim ownership of patents generated by staff, but not by students. Claiming ownership of staff innovations usually depends on whether the staff member has an employment relationship with the university; the terms of that employment relationship; and whether the innovation was generated during the course of his/her employment. Monotti (1999: 429) affirmed that Australian universities are governed by legislation that allows substantial power of self-governance in the management of institutions. This allows them to take decisions on a case-by-case basis with regard to IP ownership and commercialization agreements.

3.5.2 Decision to commercialize

Australian university staff and students are able to claim ownership of innovations arising from publicly funded research depending on the circumstances. The commercialization of an innovation is dependent on the owner and is subject to the university IP policies (Christie *et al.* 2012: 15). At universities where staff are able to claim ownership of patents arising from publicly funded research, the decision to commercialize affects patent ownership in different ways. Staff owning patents are free to assign ownership or commercialize as they wish, provided they notify the university in writing. Staff members or their assignees must grant the university a non-exclusive license to use the innovation for educational purpose, and the university retains the right to receive a share of the gross revenue generated from commercialization if that revenue exceeds Aus$50,000. Weidmier (2011: 9) stated that if a staff member fails to commercialize, the university may require that staff member to grant the university a non-exclusive licence to exploit the innovation; the staff member will be allocated a share of the revenue. The university can, for example, require a staff member to execute any document which the university deems necessary for the purpose of commercialization, or assign all their ownership rights to the university in return for a share of the profits (Christie *et al.* 2012: 15).

Students are also entitled to claim ownership of innovations produced during the course of their studies. Christie *et al.* (2012: 18) indicated that students are encouraged to make use of the university services which assist in the commercialization process. According to their IP policy, for example, some universities in Australia give students the option of assigning ownership rights back to the university, in which case the university will manage commercialization for the student and give them a share of revenue. McKay (2011: 2) affirmed that ownership arrangements are the most complex when a university claims ownership of an innovation. The majority of universities are reported to have statutes and policies in place to ensure that the decision to commercialize an innovation is made by the owner within a certain period of time. The time limit according to Christie *et al.* (2012: 22) ranges from 30 days to twelve months, with most universities allowing an eight week decision-making period. Should the university fail or decide not to commercialize the innovation, the inventor has the right to reclaim ownership. This reassignment of ownership could be unconditional, or subject to a number of different conditions. The first condition is that the university receives an agreed share of the revenue from commercialization. The second condition is that the inventor must reimburse the university for the costs incurred. In the event that an innovation is successfully commercialized, most universities grant the inventor the right to receive a certain share of the revenue. Revenue is distributed between the university, the inventor, the inventor's faculty or department, and any university owned company that is involved in commercialization. Christie *et al.* (2012: 21) explained that scales for distribution vary widely, and some require development and marketing costs to be paid back before any distribution of revenue occurs. Universities are obliged to consider the most appropriate way of exploiting the IP generated from publicly funded research, and to recognize the rights and needs of all stakeholders involved.

Walker (2010: 253) posited that the major element requiring attention is the obligation and requirement of Government funded entities to make the necessary decisions on IP commercialization. Australia's position on title vesting in the research entity is largely governed by their common law, which rules that the employee is entitled to any IPR's created by an employee in the course of their employment. Funding bodies have guidelines for IP owners to protect, manage and commercialize the intellectual property in the most appropriate manner.

Government funding agencies generally do not claim ownership of innovations created through their funds, although as previously mentioned some Government research and development corporations do, or may, require ownership. McKay (2011: 18) affirmed that institutions are free to develop and implement their own policies and that some research funding agencies provide management guidelines to recipients of funding. The commercialization of university research has not been the practice of the Australian Research Council (ARC) or the Government. The ARC does, however, recognize its role in supporting research that could lead to new enterprises. Walker (2010: 253) further stated that universities can claim ownership of innovations created by an academic staff member, both under common law and under university IP policies and statutes. In some university statutes, academics have the option to claim ownership in part or in full. Students can generally claim ownership of innovations created during their studies, although some universities modify this when university resources are utilized in accordance with policy guidelines.

As suggested by McKay (2011: 18), public sector policies need to facilitate the adoption of innovation practices and products by industry and the Government. Time limits on the commercialization of Government funded research, similar to those of the Bayh-Dole Act, should be considered. Walker (2010: 254) suggested that while there may be justification to vest the ownership of patents in the employee or funding agencies, this is best done on a case-by-case basis. The ultimate decision should be based on the successful commercial outcome and on national interests and needs. The ownership of patents should be closely aligned with aspects such as identification, protection, management and subsequent commercialization. As indicated by Christie *et al.* (2012: 28), the commercialization of publicly funded research in Australia is improving as institutions are becoming more familiar with the process.

3.6 Intellectual property in Canada

The culture of IP that has evolved within Canadian universities is similar to the environment of the USA since the passage of the 1980 Bayh-Dole Act (Trosow *et al.* 2012: 2). Over the last three decades Canadian universities have moved toward the establishment of special IP-related offices to facilitate technological innovation and the commercialization of university research (Trosow *et al.* 2012: 2). According to Statistics Canada's (2008) Survey on Intellectual Property Commercialization in the Higher Education Sector, 88% of Canadian universities were actively engaged in IP management through TTO's. The approach in Canada is similar to the Bayh-Dole Act, in that the ownership title of employee innovations would vest in the university, subject to responsibilities regarding IP management. Unlike the Bayh-Dole Act, however, the Canadian proposal lacked a means to sanction universities should they not fulfil their obligations. In 1998 the Canadian government's Advisory Council on Science and Technology commissioned an Expert Panel on the Commercialization of University Research, in order to investigate how Canada might better capture the benefits from university research. The Expert Panel concluded that the "laissez-faire approach - Let (people) do (as they choose)" of the Government was inadequate, as it opposed regulation or interference by the government in economic affairs beyond the minimum necessary to allow the free enterprise system to operate according to its own laws.

3.6.1 IP policy and ownership claims

Canadian universities do not have a uniform IP policy. Differing ownership models exist as indicated in Table 3.1. Some university policies regulate the ownership of IP to rest with the university, while other university policies vest ownership in the inventor (Trosow *et al*. 2012: 146). The diversity of university policies impacts negatively on university/industry collaboration. It has been found that the negotiation of ownership can be a time- consuming process, specifically when multiple universities with different policies are involved. Trosow *et al.* (2012: 11) stated that ownership statistics revealed that 22% of Canadian universities practice under the institutional ownership policy; 42% have the inventor ownership policy (which is the majority number); 17% have joint ownership; and 19% have no IPR policy. A representation of different models of university ownership and inventor ownership is presented in Table 3.1.

Table 3.1: Ownership policy at Canadian universities (Galushko and Sagynbekov 2014).

University	*IP ownership policy*	*Sharing of the profits (net revenue) resulting from commercialization*
University of Regina	The inventor owns IP	50% of the net revenue goes to the University when it co-manages the commercialization process
University of Saskatchewan	The university owns IP	50% of the net revenue is retained by the university
University of Calgary	The inventor owns IP	The university retains 10-25% when it is not involved in commercialization; 50% goes to the University if it co-manages commercialization
University of Alberta	The inventor owns IP	1/3 of net revenues goes to the university if it is not involved in commercialization; 2/3 of net revenues goes to the university if it manages commercialization
University of Lethbridge	The inventor owns IP	25% goes to the university if it is not involved in commercialization; the university retains 50% if it co-manages commercialization
University of British Columbia	The inventor owns IP	50% of the Net Revenue is retained by the University, out of which 25% is allocated as general University funds and 25% is allocated to the relevant Faculty, as identified by the University Inventor
University of Victoria	The inventor owns IP	The terms of income sharing are negotiated when the university TTO services have been utilized; 20% is retained by the university if it is interested in the IP but the creator chooses his own commercialization channels other than the university TTO
Simon Fraser University	The inventor owns IP	If the university is not involved in commercialization, the university retains 15% of additional annual revenues after $25,000 in annual revenue has been received by the Creator; if the university assists with commercialization, then - after the direct costs of commercialization are repaid from revenue shared on a 50:50 basis - the University retains 30% of annual revenue; if the university is not interested in the IP and does not assist in commercializing, the university retains 5% of additional annual revenues after the first $100,000 in annual revenue has been received by the creator
University of Western Ontario	The inventor owns IP	50% is retained by the university if it assists with commercialization; the university retains 25% of the net income if it is not involved in commercialization (12.5% in case of Free Standing Computer software)
University of Guelph	The inventor owns IP	The university retains 50% until the commercialization costs have been recovered if it has been involved in commercialization and 40% thereafter.

University of Toronto	IP is jointly owned by the creator and the university	25% is retained by the university if it is not involved in commercialization; if the inventor does not want to assume the legal and commercialization obligations for the invention, then the University may require the inventor to assign all his/her rights to the University in return for the first $1,000 of, and 25% of subsequent, net revenues
McMaster University	University owns IP	50% is retained by the university if it assists with commercialization; 25% is retained by the university if the inventor does not involve the university
McGill University	IP is jointly owned by the creator and the university	Where the University is responsible for commercialization, the first $10,000 of net royalties accrue to the inventor and of the balance of net income, 40% goes to the University; if the university is not involved in commercialization, of the first $100,000 of net royalties, 20% goes to the university and of any net royalties above $100,000, 30% goes to the University
Waterloo University	The inventor owns IP	Except when contractual arrangements have been made through informed consent or the university has provided direct support for the development of IP, the university assumes no *a priori* share of revenue, ownership, copyright. Reimbursement for direct support costs are negotiated between the university and the developers of the IP

The Canadian IP framework focuses on the common law principle that an employer owns innovations created by employees during the course of their employment (Christie *et al.* 2012: 27). As illustrated in Table.3.1 above, the ownership policies are divided into three main groups: (i) university ownership, which requires the mandatory assignment of ownership of the innovation to the university and the university will manage the commercialization process; (ii) inventor ownership, which provides for the decision of either assigning the innovation to the university or maintaining ownership; and (iii) joint ownership policy between the university and the inventor (Christie *et al*. 20012; Robinson 2006: 383). According to Tantiyaswasdikul (2013: 473) in the absence of a coherent national policy on IP ownership and disclosure, universities were experiencing problems in maintaining their IP portfolios. Some of the issues experienced included lost commercialization opportunities, leaked benefits to other countries, costly litigation and the limitation of longer-term innovative potential of Canadian firms. It was highlighted that a significant factor accounting for the loss of commercial opportunities was attributed to the common occurrence within universities that vested IP ownership with the researchers. Further, innovations with multiple researchers resulting in a co-ownership model made it difficult to negotiate licencing agreements (Tantiyaswasdikul 2013: 473). Conflict amongst co-owners can be detrimental to the commercialization process and could result in failure. The negotiation process has the potential to create frustrations should commonality not exist between co-owners.

A study by Galushko and Sagynbekov (2014: 8) found that the willingness on the part of innovators to commercialize largely depended on the university's IP policy. The two important dimensions of an IP policy are ownership and the division of income in the case of successful commercialization. Since there are no standardized rules that govern universities' IP policies in Canada, income sharing arrangements vary across universities (Kenney and Patton 2011: 112). Institutional policies with respect to the ownership of research results produced by academic staff members and royalty income split are summarized in Table 3.1. Galushko and Sagynbekov (2014: 10) revealed that none of the interviewees viewed royalty income as a strong incentive for commercialization. Several interviewees mentioned that they knew about the possibility of generating royalty income, however they never considered it as a motivating factor. Scientific curiosity and the translation of research results into products that can benefit the society were reported as the most important motivating factors for conducting research and pursuing commercialization.

Fini, Lacetera and Shane (2010: 1066) posited that in other situations where researchers created IP with public funds, they obtained ownership but licenced the new technology to foreign firms for development. This type of occurrence has negative effects such as the leakage of national benefits, which translates to a loss of jobs and investment in Canada. Tantiyaswasdikul (2013: 473) attested that vesting IP ownership in researchers has resulted in many universities being sued for inappropriate business decisions made by academics; for instance granting 'exclusive' licenses to more than one firm, and failing to take into account graduate student contributions to the development of an innovation. Fisher and Rubenson (2010: 116) added that the diverse range of university IP ownership policies in Canada makes negotiation over innovation ownership a time-consuming process, especially where the collaboration involves multiple universities with different policies. The negotiation process is said to create frustrations, ill feeling and mistrust between universities, academics and industry. The Expert Panel proposed to remedy the situation by requiring all universities to adopt an intellectual property policy consistent with the following principles (Gilroy 2008: 19; Christie *et al.* 2012: 62):

- Universities must recognize ‘innovation’ as a critical part of their mission.
- Intellectual property with commercial potential developed from federal funds must be disclosed to the university by the researcher.
- Intellectual property with commercial potential must be disclosed annually by the university to the Government.
- Innovations should be owned by the university, or if owned by the researcher they should be assigned to the university for commercialization.
- Universities must make reasonable efforts to commercialize innovations and maximize the benefits for Canada.
- Universities can assign innovations back to the creator if they decide not to pursue commercialization; if commercialization has been unsuccessful; or if the university and the creator both agree.
- Universities can assign innovations to private enterprise or non-university research institutions if this is necessary for the commercialization process.

- Universities must provide incentives to academics to create commercially valuable innovations, through both royalty sharing and recognition for commercial activities.
- Small business spin-offs should be given priority for licensing.
- Local industry should be given preference.
- Universities must establish organizational structures to support their obligations.

The Expert Panel had hoped that the proposed policy framework would bring about a change in the culture within Canadian universities, similar to that which occurred in the USA after the passage of the Bayh-Dole Act. Canadian universities must have the above IP policy framework in place in order to qualify for research funding (Christie *et al.* 2012: 63). There is no mention, however, of whether future funding will be denied if the policy is in place but is not observed in practice. The Expert Panel found that most academics were severely constrained by a lack of time and expertise to commercialize their innovations, and thus proposed to vest the title of employee innovations in the universities. The important aspect of the Canadian model is that it recognizes that universities are better placed than academics to manage the commercialization process (Christie *et al.* 2012: 64).

3.6.2 University-industry commercialization and initiatives

Knowledge-based collaborations between education institutions and industry impacted on Canada's private sector in becoming more innovative, and thereby providing rich learning opportunities for students. About a decade ago the Government of Canada released an innovation policy report known as Achieving Excellence, which included an initiative with respect to university commercialization (Chávez 2013: 2). The objective was to highlight conditions under which academic institutions were expected to manage public investment in research. This objective was followed by making use of three mechanisms (Langford *et al.* 2006: 10): i) universities were to commit to tripling their commercialization performance; ii) to commit to responsible co-ordination of research efforts that deliver benefits; and iii) the Association of Universities and Colleges of Canada (AUCC) agreed to produce reports demonstrating progress in transfer, commercialization and innovation.

As Chávez (2010: 3) outlined, in order to minimize key problems experienced when transferring technology to industry the appropriate marketing and management personnel were appointed at universities to assist with the process. The TTO's identified and engaged with private sector partners within the context of the alternative technology transfer mechanisms. The commercialization of research results form the basis of spin-off creation that requires skilled personnel and highly trained commercialization officers to develop spin-off companies (Fini, Lacetera and Shane 2010: 1067). Although according to Cervantes (2011: 2) access to professionals with such experience and skill sets is found to be in short supply. Rasmussen (2008: 6) found that in Canada all major research universities have various types of TTO's, with the number of technology transfer staff varying from one up to 30 persons. Canadian universities provided the basic funding for TTO's, with Government programmes providing support for maintaining their infrastructure, as previously stated. Chavez (2010: 3) highlighted that collaboration between the TTO's and the commercializing companies are key to the successful transfer technology from universities to industry. Support for entrepreneurship is generally handled at the provincial level, however, while the funding of new spin-offs stems from federal government initiatives (Rasmussen and Rice 2012: 21).

Canadian universities increasingly collaborate with industry for support and the contribution of funds from industry for research (Landry, Amara and Ouimet 2007: 219).

While provincial and federal Governments continue as the major sources of funds for research at universities, additional private sector contributions have nearly doubled in the past years (Rasmussen 2008: 506). Landry *et al.* (2007: 219) reported that there were two essential determinants for knowledge transfer from universities to industry: i) linkages between researchers and research users; and ii) the focus of the research projects on the needs of users. Academic spin-off companies have led to a recognition of the value of university commercial activities for national wealth creation, while shifting Government technology policy from a 'market failure paradigm' to a 'co-operative technology paradigm' (Djokovic and Souitaris 2008: 246).

The Canadian Government's Advisory Council on Science and Technology (namely, the Expert Panel on commercialization) recognized, however, that universities are more appropriate than academics to manage the commercialization process. It was found that most academics are severely constrained by a lack of time and expertise to commercialize innovation (Gilroy 2008: 11; Christie *et al.* 2012: 64). Furthermore, it is also recognized that productive commercialization is only possible when the inventors are actively involved and motivated in the process of technology transfer. Successful commercialization often depends on active inventor engagement and effective performance of the TTO. It is therefore essential that universities provide an IP policy mandate for academics and technology transfer offices. Additionally, it is imperative that policy makers consider creating legal frameworks that motivate collaboration between researchers, universities and industry.

Galushko and Sagynbekov (2014: 12) proffer that government initiatives have strengthened co-operation between university researchers and industry, thus facilitating the commercialization process. Galushko and Sagynbekov (2014: 1) proffered that Canadian universities have induced knowledge generation, although they have been lacking in terms of generating knowledge that translates into revenue and socially beneficial products and processes. The Expert Panel reported that to build a strong economy is neither easy nor simple, and even the best university with the greatest commitment to innovation cannot, on its own, transform an economy. Despite this, universities are making substantial and inventive contributions to local and national economies (Tantiyaswasdikul 2013: 479).

3.6.3 Financial challenges

A survey on IP management conducted amongst Canadian Universities reported that increases in IP expenditure are outpacing the income generated from university commercialization activities (Bubela and Mishra 2014: 271). This is in support of the qualitative data from TTO's, which confirms that most universities in Canada generate little IP with almost no revenue from commercialization (Brownlee 2014: 344). According to Bubela and Caulfield (2010: 344*),* "there are very few universities that actually make money off their patent portfolios". In support of the aforementioned statements, it is acknowledged by the Expert Panel that recognized commercialization has yet to be proven as a viable way to augment Canadian university budgets (Brownlee 2014: 345).

Additionally, many Government policies and programmes do not appear to be successfully assisting in commercialization attempts (Bubela and Caulfield 2010: 344). An exemplar is that of the 500 publicly funded research projects reviewed by the Centres of Excellence for Commercialization and Research (CECR) network over the last few years, only 80 were recognized as having commercial capability and of this group only 40 moved forward. The Canadian Federation of Students (CFS) indicated that "this means that 460 commercially-driven research programs, funded with public funds, failed to produce commercially viable results" (Canadian Federation of Students 2012: 16).

As pointed out by Brownlee (2014: 345), it must be noted that Canadian universities are not alone in having poor outcomes from the attempts of commercializing university innovations. Sixty percent of USA universities and 50% of British universities do not generate enough revenue from licensing activities to cover the cost of TTO's (Bubela and Caulfield 2010: 450). As Slaughter and Rhoades (2014: 3) argued, globally a very small percentage of universities benefit from their registered patents and attempts at commercialization. For the rest of the universities, commercialization activities result in little revenue, and in many cases the result is a financial loss.

Clearly, the financial problems of Canadian universities will not be solved by the commercialization of university research alone (Brownlee 2014: 246). Galushko and Sagynbekov (2014: 12) revealed that a major weakness of the current commercialization status is the reduced source of funds for basic research. They further expressed concern on the shift away from basic research and towards applied research, with the perception of a stronger emphasis on university/industry partnerships that is significantly undermining the ability to generate new ideas. A study on Canadian universities indicated that the major hindrance to commercialization was the lack of venture capital and receptor capacity, which made it difficult for scientists in life sciences to access matching funds from industry partners (Galushko and Sagynbekov 2014: 12).

The experience of Canadian universities in relation to the commercialization process was found to be different from universities in the USA. Intellectual property policies in Canada are similar to the Bayh-Dole Act in the USA, as ownership of innovations vests with the university and is subject to responsibilities regarding IP management. The factor of sanctioning is lacking in Canada, should the university not fulfil its obligation. The commercialization model in Canada highlighted that universities were more successful at managing the process than academics. The Expert Panel proposed that the benefit of ownership be vested in the university as academics experience time constraints and lack of expertise to commercialize innovations, which to an extent has been validated by the approach taken by many Australian universities (Christie *et al.* 2012: 7). Although patents are a useful quantitative indicator of a country's inventiveness, patents are only one facet of innovation. It must be ensured, therefore, that the broadest range of innovation indicators are utilized in order to capture a variety of means through which knowledge is diffused by universities. Various government initiatives have strengthened the co-operation between universities and industry in attempts to promote commercialization.

The annual report by the Minister of State for Science and Technology 2014 suggested that the Government had been integral in supporting basic and applied research, research infrastructure and innovation-related activities, with an amount of $11 billion in new federal funding since 2006. As a result of this strong commitment, Canada topped the G7 (a group consisting of the finance ministers and central bank governors of seven major advanced economies) in higher education research and development investments at their universities, colleges and research institutes. In recognition of the critical economic and social impact that innovation has on Canada, the Government presented a new strategy in 2014. The strategy was not only a vision, but also a road map for strengthening Canada's position in scientific research to harness greater innovation that creates jobs and increases prosperity, thereby improving the quality of life for Canadians (Natural Sciences and Engineering Research Council of Canada 2014: 3).

3.7 Intellectual property in the United Kingdom

In 2009 the UK Government created a new department for business, innovation and skills (BIS), whose key role was to build Britain's capabilities to compete in the global economy. This department was designed to create a single department committed to building Britain's future economic strengths; in maintaining world class universities; expanding access to higher education; investing in the UK's science base; and shaping the skills policy and innovation. The role of HEI's as important players in an innovation ecosystem was emphasized by the Lambert Review of Business-University Collaboration. This recognition was critical in contributing to the goals of the BIS department.

As posited by Mandelson (2009: 3) it has long been realized that Britain must move into high-value goods, services and industries, as UK companies cannot compete with companies in emerging economies where the cost of labour is considerably less expensive. The Government's strategy was to continue to upgrade knowledge and skills, and to compete in new and more sophisticated industries. A key input to their strategy was the role of universities in the new knowledge economy, since they produce a skilled workforce and contribute an inestimable wealth of skills and knowledge to the private and public sectors alike (Baxter 2011: 14). Universities are recognized as the single most important sources of new knowledge, thus their innovative ideas and developments can contribute to overall economic growth if they are taken up and commercialized by, or in collaboration with, businesses. Mandelson (2009: 4) stated that HEI's have a powerful second-order effect in THE knowledge exchange between firms, by virtue of their role as anchors for clusters of innovative businesses.

3.7.1 Ownership claims

The UK Patent Office guidelines recognize that research providers are generally best suited to exploit their own research results. Thus it is stated that the ownership of IP generated from publicly funded research is to reside with the research provider as the body best placed to secure exploitation, unless there are valid and compelling reasons to the contrary (Christie *et al.* 2012: 69)**.**

The Patents Act 1977 (as amended) is the main law governing the patents system in the UK. The Patents Act 1977 sets out the requirements for patent applications, how the patent-granting process should operate, and the law relating to disputes concerning patents. It indicates how UK law relates to the European Patent Convention and the Patent Co-operation Treaty. The latest amendment to the Patents Act 1977 took place on 1 October 2014, and includes the Intellectual Property Act 2014 and the Legislative Reform (Patents) Order 2014.

The UK's Patent Act 1977 provides that an innovation created by an employee in the course of normal duties belongs to the employer. This provision may only be overridden by the university's IP policy and an employment contract. Similarly to Australia, public funding for research in the UK is provided from two main sources, namely, Government departments or one of seven Government funding agencies known as Research Councils (Christie *et al.* 2012: 65).

3.7.2 The Baker report

The Ministers for the UK Treasury and the Department for Trade and Industry commissioned a report to investigate the commercialization of research in public sector research enterprises (PSRE). The main focus of the investigation was to make recommendations for increasing the rate of the commercialization of innovation. The results from this investigation were noted; this became known as the Baker Report. McKay (2011: 6) stated that the report focused on four main factors concerning IP development which were recommended to enhance the rate of innovation commercialization: i) culture and commitment to knowledge transfer; ii) PSRE/Sponsor relationships regarding IP ownership and financial freedom; iii) incentives for PSRE staff; and iv) access to commercialization expertise. These are discussed below in more detail (Christie *et al.* 2012: 66).

- **Culture and commitment to knowledge transfer -** The culture and commitment to knowledge transfer is derived from a sense of a mission to commercialize. The report noted that knowledge transfer was effectively pursued as an explicit part of the mission and culture. It also noted, however, that such a sense of mission and culture was not universal and could be encouraged more on the part of Government.

- **PSRE/sponsor relationship regarding IP ownership and financial freedom -** The report made reference to IP ownership being compromised by the insistence of the funder on retaining ownership of the IP. It was argued that delays in negotiating licensing deals are sometimes exacerbated with funding from multiple sources, each with different IP ownership policies. Additionally, problems are encountered in finding development (pre-seed) funding and resources for administering knowledge transfer activities. The report noted that problems are worsened by the lack of freedom to maintain and deploy surpluses, due to strict control over revenue by sponsors.

- **Staff incentives to commercialize IP -** The report noted that researchers were motivated by publication and peer review. Researchers require rewards to encourage knowledge transfer. The report recognized that reward and incentive schemes are now common, and encouraged Government to support this trend in making such a policy universal.

- **Access to commercialization expertise -** The report emphasized that developing IP requires specialized skills in various areas and that the right combination of skills and experts is often difficult and expensive to find. It noted that whilst some larger PSRE's may find it economically viable to employ in-house specialists, most will need to work with industry and develop networks for assistance when required.

Drawing on the above observations, the Baker Report made the following recommendations under its four headings of review (Christie *et al*. 2012: 67):

- **Culture and Commitment to knowledge transfer** - The report recommended that knowledge transfer be made an explicit part of both the research institution and the sponsors' missions. It also recommended making knowledge transfer the personal responsibility of chief executives in institutions, including the ability to lead and motivate as part of the recruitment criteria for future chief executive positions.

- **PSRE/Sponsor Relationship regarding IP ownership and financial freedom -** The report strongly recommended that IP generated by research institutions be owned by the research institution. The report emphasized that sponsors should allow research institutions the freedom to carry forward surpluses and retain receipts and other financial freedom. The report also recommended that other initiatives be taken to address funding problems faced by the PSRE, including extending the eligibility criteria of initiatives for promoting knowledge transfer. A further recommendation was to develop an accountability framework for commercialization that emphasized portfolio risk management and transparency, rather than incentivizing risk avoidance.

- **Staff incentives to commercialize their IP** - The report concluded that the PSRE chief executives should be required to have effective schemes in place for encouraging and rewarding staff participation in knowledge transfer activities.

- **Access to commercialization expertise** - The report recommended that PSRE

> sponsors encourage the development of networks amongst PSRE’s for sharing best practice in knowledge transfer and to promote synergies. It also recommended obliging PSRE chief executives to ensure that they have access to the necessary skills and experience. Ministers should consider creating a small expert unit within central government to promote knowledge transfer by, amongst other things, providing advice and encouragement to PSRE’s and their sponsors on knowledge transfer. Finally, the report noted that the Government should seek to improve the PSRE’s ability to pay market rates to attract and retain people with commercialization expertise.

Arising from the recommendations of the Baker Report, new Government policy guidelines were issued which included three key elements: i) ownership of IP; ii) responsibilities attached to ownership; and iii) a requirement to protect results generated from funding. These guidelines imposed obligations on both the PSRE and the sponsors with regard to all three elements. The first element recognized that the research providers (inventors) are generally best suited to exploit their own research results (Christie 2012: 69). The second key element covered the right of ownership needing to be accompanied by the responsibilities of research organizations to identify, protect and manage IP effectively and to pursue commercial exploitation diligently. The third key element concerned ensuring the exploitation of research results via the policy of ownership and attached responsibility. It ensured that the government and its funding bodies retain a right to use the IP generated by the fund, and that the wider public/taxpayer benefits from its investment in the research. A further imposed obligation upon research providers is to respect the right of the Government to utilize the research results for Government business in the best interest of the country.

Christie *et al.* (2012: 69) stated that an outcome from the Baker Report reflected that universities significantly increased the number of technology transfer specialists working at the IP&TTO’s in universities. Training and development was a major focus to ensure staff were appropriately trained in the field of commercialization of innovation. Effective collaboration between industry and university staff was crucial, and therefore universities needed to earmark development funds to train both administrative and research staff to build links with businesses. As stated by Mandelson (2009: 11), an example of the training obtained was with the Institute of Knowledge Transfer and the Leadership Foundation for Higher Education and Civic Leadership. This training provided specific training in the field of the commercialization of innovation. Universities also considered appointing senior outsiders to positions where increased university/industry links were built. McKay (2011: 5) reported on measures proposed by some Vice-Chancellors and research councils to tackle the recession, in particular those that involved funding new graduate employees to work part-time while undertaking technical Master's degrees to reduce graduate unemployment.

Bruneel *et al.* (2009: 66) reinforced that for the purposes of knowledge transfer and commercialization, IP is best owned by research bodies as opposed to research funders. This concurs with the policy approaches adopted in the USA and proposed in Canada, giving strong support for an approach in Australia that starts with the assumption that IP ownership should lie with research bodies (Christie *et al.* 2012: 72). The UK experience also supports the view that IP ownership should be coupled with certain responsibilities regarding IP identification, protection, management and commercialization, and that a failure to fulfill such responsibilities may require sanctions. As with the Bayh-Dole Act, the UK model is implemented via funding agreements between the funding body and the research provider. The proposed UK approach places even more emphasis, however, on the responsibilities of funding bodies to ensure that the new policy works. According to Christie *et al.* (2012: 73) besides the responsibility to commercialize publicly funded research results, research bodies must recognize that whilst increased commercialization is important, other responsibilities must not be jeopardized.

3.8 Intellectual property in India

While India remains one of the world's fastest growing economies, their cultural and educational infrastructure, together with leadership challenges, are inhibiting the growth of its innovation and commercialization efforts (Sharma 2012: 1).

The IP regime in India has undergone various significant developments with respect to laws and policies. The Patents Act 1970 is a landmark in the industrial development of India. The function of this Act is to grant patents to encourage innovation; to ensure that the innovations are worked on a commercial scale without undue delay; and that patents are not merely granted to enable the patentee to enjoy a monopoly but also for the importation of patented products into the country (Verma 2011: 1). Thus, the Patents Act 1970 was expected to provide a reasonable balance between an adequate and effective protection of patents on the one hand, and technology development in the best interest and specific needs of the country on the other hand. Chakraborti (2011: 90) stated that the Third Amendment of the Patents Act 1970, by way of the Patents (Amendment) Ordinance 2004 which came into force on 1 January 2005, incorporated the provision for granting product patent in all fields of technology, which remains in force.

To compete in the global environment and to promote creativity and innovation, India realized the need to protect and utilize the intellectual property created out of publicly funded research and development. Nandagopal (2013: 183) explained that the translation of research from universities into products and services in the marketplace takes considerable and sustained effort. It is believed that dedicated TTO’s and supporting systems are required to achieve this, together with devising flexible models to work with various commercial partners bringing in external funding to further advance technology goals. It is found that India does not have established TTO’s to perform the crucial role of commercializing academic technologies (Chakraborti 2011: 93). There is therefore an urgent need to improve systems in the TTO's and to establish models to commercialize technology developed at research institutes and universities. Sharma (2010: 257) reported that apart from the elite scientific institutions, only 5% of the research organizations have TTO's. There are very few skilled people to handle technology transfer and commercializing licencing in India, which places universities at a disadvantage in attempts to generate third stream income.

3.8.1 Protection and utilization of Public Funded IP Bill (PFIP) 2008

The Government of India introduced the protection and utilization of the Public Funded Intellectual Property Bill (PFIP) 2008, with the intention of increasing commercialization activity at universities (Sharma 2012: 255). This Bill had been modelled on the commonly known Bayh-Dole Act, which sought to provide incentives to create intellectual property and the mechanism for its protection and the utilization thereof. The main focus of the Bill is highlighted below (Srivastava and Chandra 2012: 124):

- The bill seeks to provide incentives for the creation and commercialization of IP from public funded research.

- It requires scientists to immediately inform the research institution once IP has been created. The institution must disclose this information to the Government within 60 days.

- The institution is required to inform the Government of the countries in which it proposes to register and retain title of the intellectual property. The title in all other countries will be vested in the Government.

- The scientist shall be paid a minimum of 30% of net royalties generated from the IP. Failure on the part of the scientist to inform the institution, or failure of the institution to inform the Government, carries penalties which include fines and the recovery of the grant funds.

Various stakeholders were invited to comment on the Bill. As the environmental conditions of India differ from those prevailing in the USA, stakeholder comments found that the Bill may not be appropriate in a developing nation such as India.

The Bill was formulated to revitalize research at universities, to give impetus to publicly funded research, and to give universities and research institutions ownership and patent rights over innovations arising out of Government funded research. This Bill further created an enabling environment for the commercialization of innovation through licensing arrangements, where innovators were included to receive a benefit share of royalty income. At the time of this study, however, the Bill has not as yet been passed into an Act.

Intellectual property legislation attracted both positive and negative feedback from various stakeholders. While industry in India works on the principle of profit-making and operates in an environment of competition, university/industry association might deviate from the path of knowledge dissemination for revenue generation (Sharma 2012: 256). It was also felt that by providing discretionary power to the universities involved in research, the Government of India may lose its authority over innovations which should be used for the general masses.

3.8.2 Science technology and innovation (STI)

The Science, Technology and Innovation policy (STI) emerged in 2013 as a major driver of national development globally. The aim of the Indian Government was to create a strong and viable Science, Research and Innovation System for High Technology in India (SRISHTI). India declared 2010-2020 as the 'decade of innovation'. It aimed to bring fresh perspectives to innovation in the Indian context.

One of the key initiatives of the STI policy was linking contributions of science, research and the innovation system with the inclusive economic growth agenda. By doing so, it is hoped to include the following key factors (Science Technology and Innovation Policy - India 2013: 5):

- The transfer of science and technology high-risk innovations through new mechanisms. The establishment of a fund specifically for innovation for social inclusion called 'small idea-small money', and a 'risky idea fund'. The main initiatives are the provision of funds to remove the sluggishness in the ecosystem for innovation through improved linkages.

- The establishment of an innovative mechanism to foster partnerships between academia and industry. Increased mobility of experts between academia and industry will be facilitated. A regulatory framework for the sharing of IPR's between inventors and investors will be implemented. Mechanisms will be devised to transfer new R&D findings and grass roots innovations into the commercial space. These initiatives should address the challenge related to linkages and facilitate understanding within such partnerships.

- To promote science and foster resource optimization for cost-effective innovation across all technology domains. New science education reforms are established to improve the teaching methods and curricula for the identification of talent. In this way, the policy addresses the need for educational reforms.

- The policy seeks to establish a framework for the creation and sharing of IP for a robust innovation system. The framework will enable strategic partnerships and alliances with other nations through bilateral and multilateral co-operation in science, technology and innovation. Science diplomacy, technology synergy and technology acquisition models will be judiciously deployed, based on strategic relationships. This initiative is important for international collaboration.

- Enabling policy instruments that facilitate institutional research and R&D enterprises to focus on innovation efforts. The policy accepts risk as an integral part of a vibrant innovation system. It also emphasizes risk sharing by the Government and to increase private sector investment in R&D. Technology development and financing mechanisms would be created for investing in enterprises without a fear of failure.

- The complex value chain of innovation from idea to market often calls for STI intervention at all levels in priority areas of socio-economic importance. The policy will enable a holistic approach in addressing the innovation value chain. In this way, it is hoped that the policy will shape the future of India. With the advantages of a large demographic dividend and a large pool of young talent, the policy foresees the achievement of national goals for sustainable and inclusive growth.

- The STI input into the manufacturing sector can lead to the enhanced generation of employment. The policy indicates Government's support in building delivery mechanisms that take the fruits of this policy to the people of the country.

According to Abhyankar (2014: 1) there has been a substantial thrust toward science, technology and innovation, however the investments are not as yet being translated into the desired results. Realizing that innovation-led entrepreneurship development holds promise for growth, the government of India has taken major policy initiatives with a strong innovation agenda (Science Technology and Innovation 2013: 2).

The Science, Technology and Innovation Policy initiatives are aimed at achieving India's innovation goal for economic growth. It addresses the key challenges in developing an effective innovation ecosystem. The main initiatives are the provision of funds, the removal of sluggishness in the ecosystem by improving linkages, and establishing a vibrant system in a comprehensive way (Abhyankar 2014: 2).

3.8.3 University-industry collaboration

India's Science, Technology and Innovation policy (India 2013: 6) states that the ability of a country to sustain its economic growth, increase the standard of living of its citizens, and improve human health, depends directly upon successful development and access to new products, processes and services. Sharma (2012: 1) stated that India's main challenge is the shortage of the necessary support mechanisms that enable innovation commercialization, venture capital funds and start-up capital, as well as awareness programmes and initiatives. He further stated that "the lack of these support systems has resulted in a limited number of innovative ideas, relatively few motivated individuals, and subsequently, very few or minimal incentives for people to generate innovative ideas" (Sharma 2012: 1). The country therefore needs to address the issues that hinder technology transfer, such as the absence of an active technology transfer mechanism; the lack of funds to prepare primary innovations to a transferable level; and an institutional attitude that limits research to just publishing in journals (Department of Industrial Policy and Promotion 2014: 7).

As reinforced by Nandagopal (2013: 181), researchers are motivated by publication output rather than by patenting and commercialization that could advance the impact of their efforts. This is supported by Sharma (2012: 2), who stated that, “innovators in the Indian society are risk-averse, their lack of tolerance toward failure instills the fear of taking risks ... thus making it difficult for them to generate innovative ideas or to promote existing ones". It was therefore considered difficult to implement the objectives of the Science Technology and Innovation Policy 2013 in the absence of a progressive mechanisms for the encouragement of research, licensing and the transfer of knowledge. It was further found that few university researchers took an interest in projects relevant to industry. Nandagopal (2013: 185) indicated that their technological watch was limited to scientific conferences and the publication of their work in scientific journals. India does not have the advantage of a law to promote the establishment of TLO’s with the authority to manage university innovations with incentives to the inventors, their laboratories and the university. India also does not have a mechanism by which R&D relevant to industry can be incentivized through structures that stimulate growth in university/industry collaboration (Sharma 2012: 7). The 2013 Science Technology and Innovation Policy states that research output emanating from publicly funded R&D is to be commercialized for the benefit of the citizens.

The Department of Industrial Policy and Promotion (2014: 11) stated that India needed to create an enabling policy framework for stronger university/industry collaboration, and for the creation of a sustainable competitive advantage in their manufacturing approach. Contract research would enable universities to receive projects from industry. The result of such research would belong to the university, however it must be reported to industry with first option to licence (Science Technology and Innovation Policy 2013: 12). Human resource development for the strengthening of the innovation eco-system was necessary across the entire value chain, from idea to market, licensing, technology transfer and for the management and commercialization of technology.

The STI enterprise found that the knowledge flow from laboratory to industry was not effective at public funded research institutions (Science Technology and Innovation 2013:16). This was addressed by a process that brought about uniformity to effectively map intellectual property, technology transfer and to provide incentive benefit to scientists and innovators.

3.9 Analysis of intellectual property systems

Variations are found in the commercialization of innovation systems amongst the different countries. Prior to 1980, the lack of a uniform IP policy governing ownership and the lack of incentives to commercialize innovation was a challenge for the USA. The situation was corrected by the introduction of the Bayh-Dole Act, as opposed to Australia where the university commercialization environment imposed limitations and controls in their activity that satisfied national standards. In doing so, commercialization interests did not displace the principles of academic freedom and the integrity of research.

Ultimately, the Bayh-Dole Act gave USA universities the opportunity to take ownership of innovations, remove the Government from the process, and provided incentives for commercialization to occur. Thus, by revenue sharing between the university and its researchers, the Bayh-Dole Act strengthened incentives for researchers to become entrepreneurial and to participate actively in the commercialization process. This was also the case in countries such as the United Kingdom, Japan, Germany, Austria, France, Denmark, China, and the Republic of Korea. This is not an imperative for successful technology transfer, however, since in some of the leading innovative countries of Europe (such as Finland and Sweden) researchers or their faculties own the IP generated at such universities. Some believed that the Bayh-Dole Act could adversely affect the quality of university research, however there is limited empirical evidence to this effect.

Innovation activity based on university-generated IP has been on the increase in the USA, Western Europe and Canada, however literature suggests that the European Union has been lagging behind the USA. It was also found that older knowledge transfer offices produced fewer innovation disclosures, patent applications and grants as compared with younger offices. As knowledge transfer offices gain in experience, it becomes easier to weed out research results with poor commercial potential and to focus attention on the commercially promising technology.

Each country's IPR's policy, procedure and regulations has its own strengths and weaknesses that results in challenges and successes. For example, the higher education sector in Australia has a well-developed system that is strongly subsidized by their Government and focuses on adding value to key primary products in the mining and agricultural sector.

A case study of Japan, Finland, Canada, and the Flanders region of Belgium found that these nations changed their national innovation strategies to increase R&D spending, collaboration between industry and academia, and new technology start-ups (Wessner 2013: 6).

Germany's ability to remain globally competitive in advanced manufacturing exports, despite wage and other costs that are higher in comparison than in the USA, is possible through being a mature industrialized nation. Although the German patent system was known to be similar to the American system, it was considered more stringent, thereby resulting in a lower number of patent grants although likely higher in average value. Their patent examination process requires the patent to be new, non-obvious, and also capable of producing greater efficiency. As with the USA system, the courts adopt a liberal attitude in interpreting and enforcing existing patent rights once granted. Penalties for willful infringement include not only fines but also the possibility of imprisonment. Unlike USA policies, German patents were subjected to working requirements. The grant of a patent could be revoked after the first three years if the patent was not commercialized and if the owner refused to grant a licence for the use of an innovation that was deemed in the public interest, or if the innovation was primarily being exploited outside Germany.

Canada and the United Kingdom have similar IP systems to the Bayh-Dole Act style approach. The failure of research institutions to take responsibility for IP management stems from the Canadian system, which arises out of the laissez-faire approach to IP ownership. Both the Canadian and the UK experience may therefore find the solution of research bodies being the most conducive owners of IP.

Although the Finnish system was not discussed in detail, it was found to be comparatively different from other countries which emphasize funding instruments that promote research collaboration within and between higher education and the business sector. The strong emphasis is both on human capital and areas for industrial innovation. Canada proposes that research bodies give priority to local industry and small business when licensing IP, while the UK on the other hand considers such an obligation unrealistic and inconsistent with the global nature of industry. Although the Chinese IP system was not evaluated in detail for this study, it is known to have similar ideas to India. Both nations have innovation agendas for improving living standards and moving into high-tech knowledge-intensive industries. Their systems attract foreign investment in industries which are found to develop global competitive corporations. According to Breitwieser and Foster (2012: 69) the existing empirical literature suggests that the effectiveness of patent protection in India varies from industry to industry, and inventive activity is sensitive to protection only in selected spheres such as the chemical and pharmaceutical industries.

Chile has changed their IP system from a mixed system of government laboratories and universities, to a system similar to the Finnish model. The common points shared by the UK and Canadian proposals for reform of university IP management systems are summarized below (Christie *et al.* 2012: 73):

- Intellectual property should be vested in the research bodies. Experience in the UK and the USA supports this statement and reveals that for the purposes of commercialization, IP created by the employees of research bodies is generally best owned by the research bodies as opposed to the research funders.

- Intellectual property ownership should be coupled with responsibilities designed to encourage research bodies to implement strategies and systems to identify, protect, manage and exploit valuable IP. The UK and the USA experiences support the view that IP ownership should be coupled with certain responsibilities regarding IP identification, protection, management and commercialization, and that a failure to fulfill such responsibilities may require sanctions.

- Knowledge transfer should be included as an express objective of research bodies. The Canadian and UK policies support and emphasize the importance of incorporating knowledge transfer as an express part of research bodies' missions.

- Intellectual property owned by research bodies should be disclosed to the government on a regular basis. This view is supported by the UK, India and Canada, which also require disclosure of all intellectual property owned by research bodies to the government on a regular basis.

Countries have fine-tuned their intellectual property right regimes as per their developmental requirements. Against this backdrop, there is an ongoing attempt to harmonize and strengthen intellectual property protection regimes worldwide. The TRIPS agreement is seen to be adversely affecting the technological activity in developing countries, with negative implications for the access and affordability of life-saving drugs by the poor (Breitwieser and Foster 2012: 51).

3.10 Conclusion

It is difficult to make an assessment of which country's strategy and policy will continue with success. Policy options found appropriate in one country may be completely challenging for another country, yet all responsibilities are aimed at encouraging strategies and systems to identify, protect, manage and exploit valuable IP in the best interests of each country. The literature also suggested that a strong IP regime may also inhibit the diffusion of knowledge and technology development, especially in countries that are technology followers. Valuable insights for decision-makers and policy-makers have been discussed, which presents a holistic picture of the continually changing global context.

The next chapter focuses on the role of IPR's in technology diffusion and economic development. The importance of university/industry collaboration, including the benefits and challenges, will also be covered.

Chapter 4

INTELLECTUAL PROPERTY, ECONOMIC DEVELOPMENT AND UNIVERSITY INDUSTRY COLLABORATION

4.1 Introduction

Education and the generation of knowledge were traditionally the key roles that universities performed in society. They have taken on a further mission by fostering links with industry partners for the facilitation of commercialization. Universities are therefore considered as business entities because of the potential amount of revenue that can be generated from the commercialization of IP. More importantly, their new mission has the potential to create direct and indirect employment in various sectors of the economy. Innovation has therefore become a key asset for universities, firstly by the generation of income, and secondly by making them a major contributor to a country's economic growth.

Whilst commercialization represents a route for academic research to contribute to the economy and society, there are various other avenues through which university research can be transferred (Baxter 2011: 9). These interfaces include activities such as collaborative research, contract research and consulting, as well as informal activities such as providing *ad hoc* advice and networking (Perkmann and Salter 2012: 80). Commercialization is the most effective route for creating academic impact, as it achieves immediate and measurable market acceptance for the output of research (Markman *et al.* 2008: 1403).

4.2 Commercialization activities at universities

The conception of commercialization of academic research from patent activity began in 1907 at Berkeley University in the USA. During that period Frederick Cottrell of the University of California patented his electrostatic precipitator, a device that extracted particles from the air. This innovation and subsequent patent drew attention in higher education, as it instigated the commercialization of academic research (Metlay 2009: 569; Mowery and Sampat 2001a: 321; 2001b: 798). After developing the innovation in 1912 Cottrell further set up a Research Corporation, a patent management organization that relieved innovators from undertaking the bureaucracy allied with the patent process. These events marked the start of a new era in the commercialization of academic research (Baez and Sun 2009: 78).

According to Landry *et al.* (2007: 218) the commercialization of university research is a transaction between the university and a commercial firm. Notable mechanisms of commercialization can be considered through consulting activities, research contracts with industry, patenting, and spin-off company formations (Landry *et al.* 2007: 218). Many of these mechanisms extend beyond licensing, often resulting in economic and social impact. An illustration of the technology transfer and commercialization process is found in Figure 4.1.

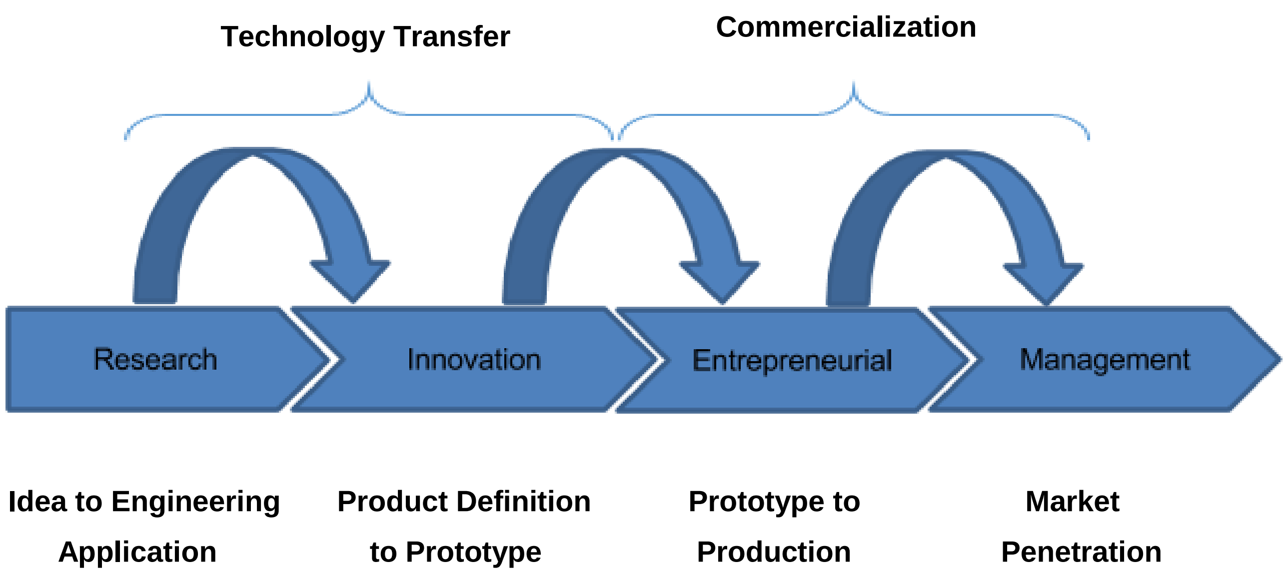

Figure 4.1 Technology transfer and commercialization (adapted from the US Department of Energy 2008).

As indicated by Figure 4.1, technology transfer is the process of moving research findings from one place to another, for example from a laboratory to the marketplace. Commercialization is the process of the introduction of a new product outcome into the marketplace. Figure 4.1 contextualizes the process of technology transfer and commercialization as illustrated by the Department of Energy (DOE) (2008: 4), which provides clarity on the process.

Through technology transfer the movement of know-how, skills, technical knowledge, procedures, expertise and technology from one organizational setting to another is facilitated (Roessner 2000: 3). It also includes the transfer of innovation from a university environment to industry, thereby generating economic value and increasing industry development. The process of technology transfer is thus rewarding for any research-based institution and innovator who actively attempt to achieve the most successful and positive results. These efforts result in new products, services and jobs. From an academic perspective, university technology transfer can be translated from a researcher's presentation of basic research at a conference or the publication of a journal article.

Merrill and Mazza (2010: 14) reported that universities provide conducive environments for the generation of new ideas and the spurring of innovation, together with moving advances in knowledge and technology into the commercial stream for the public good. These actions are collectively referred to as 'technology transfer'. The transfer of technology is the diffusion of knowledge through three major mechanisms, including conferences and scientific publications, the training of a skilled labour force, and the commercialization of knowledge (Landry *et al*. 2007: 217). A clear understanding of the term *'technology transfer'* assists in the better understanding of the term *'commercialization'.*

Zuniga and Correa (2013: 2) posited that commercialization refers to the valorization of research and intellectual assets by industry, or the transfer of an idea to the market whilst creating financial value. This implies the selling, licensing, or contracting of technology services, intellectual assets, and related-knowledge into spinoff creation and R&D collaboration. By improving the process of knowledge transfer, countries can foster innovation to raise productivity, create better job opportunities and address societal challenges for economic development.

The eventual product of research is the formation of new, useful knowledge. Substantial time, capital and labour are invested by the person who has undertaken research that results in innovation. Garduno (2004: 2) highlighted that knowledge is a creation which by its very nature can be shared and be transferred from one person to another. Thus, the new knowledge exemplified in research discoveries can be distributed to others with ease. This characteristic, the diffusion of knowledge, has advanced mankind but has also inhibited further progress. North (2010: 164) described the scenario below:

> Throughout man's past he has continually developed new techniques, but the pace has been slow and intermittent. The primary reason has been that the incentives for developing new techniques have occurred only sporadically. Typically, innovations could be copied at no cost by others and without any reward to the inventor or the innovator. The failure to develop systematic property rights in innovation up until fairly modern times was a major source of the slow pace of technological change…

The scenario above describes the importance of a system with incentives that encourage technological change, while creating a rate of return on innovation; this was a solution established by the patent system. Furthermore, the enactment of the USA Bayh-Dole Act and the South African Intellectual Property Act 51 of 2008 brought about the much-needed IPR legislation that provides an incentive for innovators to continue with their creativity.

The Bayh-Dole Act of 1980 signified an enormous event for the commercialization of publicly supported academic research (Gulbrandsen 2007: 1156). This legislation granted universities ownership of patent rights and the associated license revenue from government funded projects. Patent activity at universities amplified considerably after the enactment of the Bayh-Dole Act (Bradely, Hayter and Link 2013: 2). During the decade before the Bayh-Dole Act was passed, the USA Patent and Trademark office allotted less than 400 patents each year to universities that signified the top 100 universities in R&D. By 1985 the amount of patents issued to these universities increased to 587 and by 1991 there was a further increase to more than 1300 patents. During this time, the quantity of patent applications and licenses by American and Canadian universities increased by 220% and 160% respectively (Association of University Technology Managers 2003:1). The regulation advanced its purpose of commercializing research and spurred on innovation by patent and licensing activities at universities.

Similarly, the South African Intellectual Property Rights Act 51 of 2008 was modelled around the Bayh-Dole Act.

With the emergence of the Bayh-Dole Act the concern over the commercialization of academic research increased substantially after 1980 (Seeley 2009: 13). Universities engaged in 'commercialization', the process of converting knowledge and discoveries into commercial application, which established patent and related IP activities such as licensing and marketing. As a result, IP&TTO's were set up at universities with the precise intention of commercializing research. Literature reveals that most university patents are not commercialized, while the patents that are commercialized do not generate sufficient revenue (Powers 2006: 3). Research activities are still pursued for the potential financial rewards. Sun and Baez (2009: 83) proffered that the general expectation is that when university patents are mentioned the public thinks about big patent winners. Ellis (2013: 1) reported that many leading USA universities fail to profit from commercialization; in fact, universities do not generate enough to cover the operating costs of their IP&TTO's. Literature further reveals that the average IP&TTO break-even on overhead costs after an approximate fifteen year period, before profits are generated. This is further supported by reports that estimate 130 universities in the USA did not generate enough revenue from licensing during 2012 to cover the costs of filing patents (Ellis 2013: 1).

Although ongoing debates have expressed differing conclusions on whether universities should engage in commercialization, the activity in advancing innovation has been encouraged by most countries, including South Africa, for the purpose of national economic growth (Bansi 2012: 13). Advocates of university patents argue that IPR's allow academic scientists and universities to support a knowledge flow that benefits the public. Adversaries of university patents argue that IPR's limit access and permit one party to dictate the direction of an innovation, which opposes academic culture and scientific inquiry (Mowery *et al.* 2001 cited in Bansi 2012: 72; Nelson 2001 cited in Bansi 2012: 72). Contrary to ongoing debates, literature presents four reasons in support of patenting activities at universities (Sun and Baez 2009: 84):

- **Acknowledgment of the innovators** - University patents acknowledge innovators (Campbell and Slaughter 1999: 322). Patents provide proper recognition to innovators involved in the creation (Bradley 2009: 12). The registration of patents recognizes listed innovators by way of a national recording which appears in a publicly accessible record. Financial rewards are often negligible to innovators, as acknowledgement serves as an important symbolic reward. Attribution also provides the incentive for innovators to continue with creative activity.

- **Control of the innovation quality** - Patents are controlled by the university for quality (Metlay 2008: 567; Mowery and Sampat 2001a: 341). According to Sun and Baez (2009: 84) when the fortification process for vitamin D was discovered by Professor Harry Steenbock, the reason for patenting was to regulate the quality of the product. Intellectual property rights ensure control of the manufacturing process that translates into manufacturing integrity. The adverse of this process can be illustrated by a circumstance where an inventor does not patent his/her innovation; the lack of control can result in the distribution of poor-quality products. Aside from retail consumers experiencing problems with the product, the quality control challenge could jeopardize the reputation of the university and the inventor. The advantage of university patents therefore presents a degree of control.

- **Accessibility to the innovation** - University patents permit greater access to innovations (Kesselheim and Avorn 2005: 851; Pressman 2006: 36). Sun and Baez (2009: 85) reported that other studies on licensing do not divulge that exclusive licenses issued by a university include humanitarian exceptions. Universities are better conductors of innovation than industry because academic scientists, by their professional culture, are more inclined to avail the innovation to a greater scope of users which spurs downstream product development (Ramirez 2004: 366). With university patents, the academic community is less inclined to operate in a manner that monopolizes the innovation and strictly controls the licensing to drive control and unethical practices (Metlay 2009: 568).

- **University mission aligned with public interest** - In keeping with research for the public good, university associations with patent activity fits this mission more than other organizations, including government service entities (Pressman 2006: 36). Universities are therefore more appropriately positioned to serve as keepers of innovations, due to their nature of sharing innovations for the betterment of society.

Other literature in support of university patenting is the European Commission Green Paper (2007: 16), which recognizes that university ownership of patents is important for knowledge dissemination. Further initiatives by European universities are to promote effective knowledge sharing, which concurs with the support of university ownership of patents (Joaquin 2009: 3). In addition to the traditional criteria of teaching, publication and research output, patent ownership is regarded as an added justification for fund allocation to universities and as a precondition for licenses.

4.2.1 Arguments opposing patenting by universities

There are some opinions that oppose university patenting activity, as it is said to be a shift away from a sphere of communal use. As outlined by Metlay (2006: 566), patents transform the scientific norm of open access to a norm of proprietary interests. Stein (2009: 7) concurred with Metlay (2006: 566), in that IP in academic science changes scientific norms of openness, as it changes the environment for academic/scientific work. Sun and Baez (2010: 86) reported that opposition to university patents rests in the following five points:

- Patents run counter to universities' public service role. If public funded universities are meant to serve the public, their research should be free, accessible and universities should not financially benefit from those innovations (Metlay 2009: 569).

- Cohen and Walsh (2007: 39) found that patents encourage various forms of data blockage, for example the withholding of data and the secrecy of academic research. When research has been subsidized by public funds, the argument for public access strengthens.

- Patents require a declaration of an innovations' usefulness or purpose; the movement towards more university patents encourages applied research over basic research (Nelson 2002: 6).

- Innovations with multiple patents require many layers of licensing approval that stifle scientific progress. Many have argued that the registration of multiple patents complicates the research process, as the barriers to the patenting of scientific studies became onerous (Shapiro 2011: 127).

- De Larena (2007: 1388) reported that patent activity adds additional costs to the depleting budgets of universities. Literature reports that commercialization as measured through patents and licensing occurs at a loss; universities cannot afford to patent every innovation. A university should evaluate the possible value and feasibility in light of the projected expense.

The argument opposing universities is further extended as universities are seen to be running counter to their public service duty by data secrecy, thereby creating layers for licensing approval that strongly hinder progress, and incurring additional costs for public access by the assertion of IP rights (Krikorian and Kapczynski 2010: 271). This is supported by Hunt (2011: 11), who argued that patent activity at universities have been known to limit knowledge flow by delaying research progress in the higher education community and to the public, but retaining benefit at the individual level.

Although the importance of patent registration is noted, more critically the commercialization of patents becomes necessary as it contributes to the advancement of society on many different levels. As argued by Orsenigo and Sterz (2010: 7), patents are fundamental in disclosing information on innovations which might otherwise have been kept secret. In the absence of patents, investors would not invest in R&D based on new discoveries as anyone could have access to them. Patents allow for the exploitation of such knowledge, thereby avoiding the wasteful duplication of efforts (Orsenigo and Sterzi 2010: 9). Patents only become valuable to universities once commercialization has taken place. University investment in patent registration has increased despite the dwindling budgets from Government. The situation as quoted by Dell (2010: 1) therefore, and further argued by Moore (2009: 1), where patents lie idle at universities without benefit accruing to the university, needs to be addressed by encouraging commercialization.

4.3 Intellectual property rights protection and technology diffusion

Generally economies have moved into information economies, forcing the concept of IPR's to become increasingly important. This is supported by Du Plooy (2013: 1) who reported that IPR's can be enablers for technological innovation and for accelerating the diffusion and transfer of new technologies. This is further reinforced by Maskus (2000: 13), who stated that IPR's can accelerate the diffusion and transfer of new technologies and that their benefits are greater than their costs. Diffusion therefore refers to the stage at which technology spreads to use, and application within the user environment, after

IPR protection has been identified as illustrated in Figure 4.2. The most important form of property in the information economy is ‘intellectual property’, being the creative products of the human mind. Intellectual property rights have therefore been recognized as fundamental for innovation to thrive by increasing productivity and living standards. Furthermore IPR’s stimulate creativity, thereby encouraging the creation of innovative products which results in a broader consumer choice of new technology.

Various forms of IP, such as patents, trademarks and design rights, are the principal means for the establishment of ownership rights over ideas. These rights provide the legal foundation for intangible ideas and creation to generate tangible benefits for the inventor and society. It is therefore necessary for innovation to be protected by rights that award innovators control over their creations. The many economic and societal gains acquired from innovations are therefore greatly reliant on active IPR protection.

The IP rights afford an innovator the power to preclude others from using a creation, and to control the terms on which it can be utilized. Although the policy of open access produces benefits in the short term, it harms the incentive of continued innovation. In general research is considered a high risk investment. Returns on fruitful R&D must be large enough to compensate for the percentage of innovation that does not produce a return on investment. In this way, an average return on R&D is collectively generated. The rate of return on investment is dependent on the rate of diffusion, which includes the diffusion of technical information on ensuing approval of new technologies and techniques by users.

Falvey and Foster (2006: 1) asserted that knowledge is naturally non-excludable, in that it is not possible to prevent others from applying new knowledge without the authorization of its inventor. When technology becomes valuable it is more likely to be imitated, thereby decreasing the possible profits of the original inventor and potentially eliminating the incentive to participate in further innovative activities. As 'imitation' has lower costs than 'innovation', imitators have the advantage over innovators unless IPR protection restricts access to the innovation. This characteristic provides the argument for strong IPR protection. These rights allow the inventor to set the terms in which the intellectual creation can be used. The resultant monopoly profits afford the yield on fruitful investment in R&D. As illustrated in Figure 4.2, these innovations could either be novel (new to the world), imitative or adaptive. Intellectual property rights systems play a significant influence on the entrepreneurial activity.

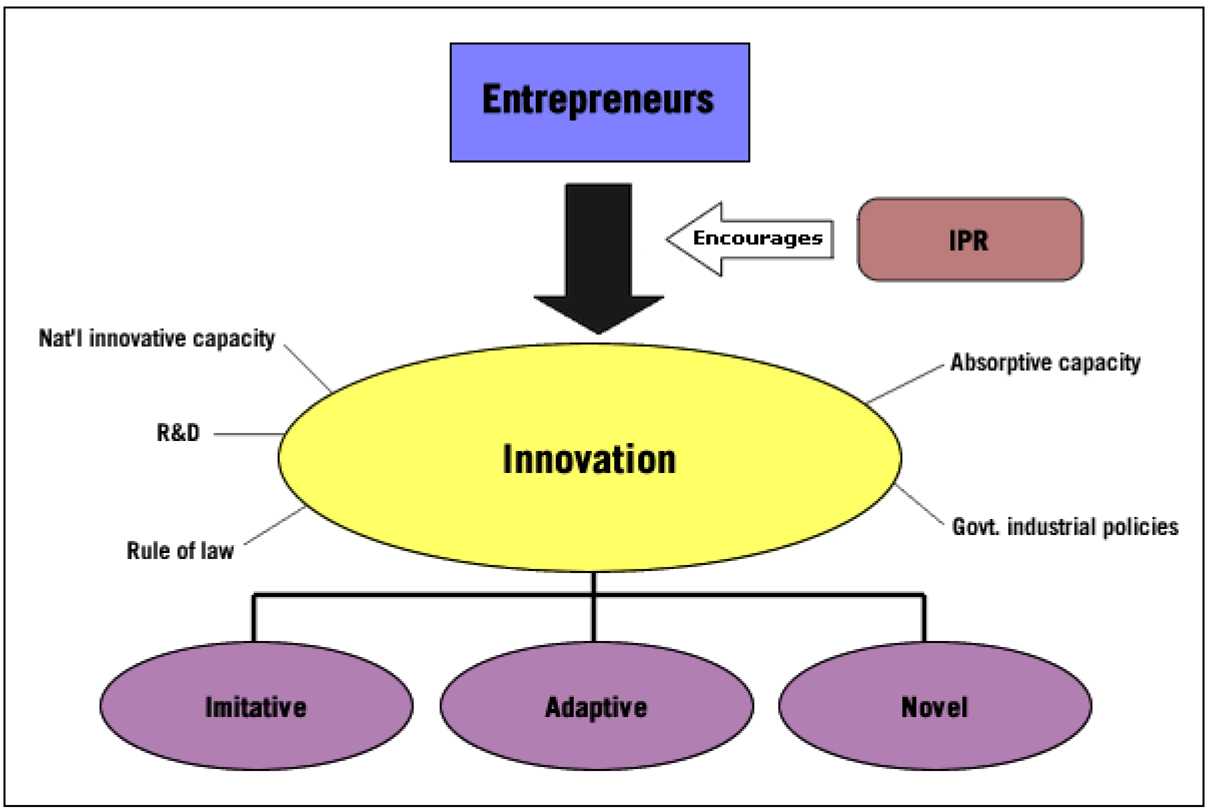

Figure 4.2 Influences and significance of intellectual property rights protection (adapted from Kamara 2012).

Figure 4.2 illustrates the influences and significances of IPR protection that surrounds innovation activity; IPR protection functions as the mechanism that encourages innovators to participate in further innovative activities. The types of innovations that one participates in depends to a large extent on the country's national innovative capacity, its absorptive capacity, and the Government's industrial policies which include R&D policies as illustrated in Figure 4.2. As expressed by Breitwieser (2012: 9), the choice of an IPR policy therefore reflects a choice in the balancing of considerations. Indication advocates that IPR protection motivates innovation and that the rate of return on investment is considerably higher (Mansfield *et al.* 1977: 223). The award of a temporary monopoly increases and restores the incentive to innovate, thereby encouraging long-term growth and enhanced product quality.

It is believed that awarding innovators too much protection may also limit the spread of new ideas, which results in permanent monopolies. Although to the contrary, IPR is primarily to grant innovators a temporary monopoly allowing them to reap a positive return on R&D. It is found that IPR's stimulates R&D and innovative activities, with the demand for IPR protection being stronger in countries that are more innovative. Emmon's (2009: 26) study, which is also supported by Falvey and Foster (2006: 6), revealed that the strengthening of IPR's can be growth-enhancing thereby resulting in higher growth in open economies. This is reinforced by Pham (2010: 11), who argued that once tangible goods and services are protected through strong IPR's then consumer demands are increased, thereby creating job opportunities for economies to grow into advanced societies.

In some instances, stronger IPR protection restricts diffusion of proprietary knowledge with increased market power, possibly decreasing the diffusion of knowledge due to lower output and higher prices. In other instances, IPR's can play a positive role in knowledge diffusion as patent specifications are records for public consumption. Breitwieser and

Foster (2012: 2) reported that the impact of stronger IPR protection on innovation diffusion is ambiguous in theory, and depends on each country's circumstances. Individuals producing imitations have an advantage unless access is restricted by IPR's. Countries with a technological lead are sometimes disadvantaged by countries that have caught up with imitation (Correa 2000: 4). The major reason why pressure was applied on national Governments to strengthen international IPR regimes, therefore, was to prevent the increase of imitation. The Trade Related Aspects of Intellectual Property Rights (TRIPS) agreement, a product of the Uruguay Round (1986-94) of trade negotiations, was the outcome of countries strengthening IPR regimes. The TRIPS is the first comprehensive, global set of rules covering IPR protection.

The anxiety of advanced countries such as the USA, and countries of the EU in particular, was one of the factors that resulted in the formulation of the TRIPS agreement. Breitwieser and Foster (2012: 3) explained that the Governments of developing countries felt that approving TRIPS would inspire negotiations for broader access to markets in developed countries. In addition, business benefits within many developing countries stimulated Governments to embrace stronger IPR protection in order to protect their own innovative activities. As reinforced by WIPO (2012: 1), stronger protection is also recognized for increased imports; inward foreign direct investment (FDI); technology licensing; and protection for consumers by regulating the trade of counterfeit goods in order to expand international trade activities.

The TRIPS set the minimum standard of protection to be provided by each World Trade Organization (WTO) member country, as well as requiring countries to improve mechanisms to enforce these rights. For most developed countries, compliance with TRIPS required minor adjustments of their national IPR systems; for developing countries, however, TRIPS implied increased levels of IPR protection in line with international standards. The TRIPS Agreement accommodates countries to follow different policies with respect to IPR protection, although it does specify the minimum standards that should be attained within an elected period of time. The various aspects of IPR protection covered by TRIPS are expected to have a variable degree of impact on innovation diffusion in the different countries. This is subject to the implementation of IP legislation in an individual country.

There are numerous convincing reasons for the promotion of IPR's; amongst others, the well-being and progress of humanity depends on the capacity of IPR. The promotion of IP increases economic growth, generates new jobs and industries that ultimately enrich the quality of life. The lawful defense of creations reassures the commitment for further innovation. According to WIPO (2012: 7) an efficient and equitable IP system assists all countries in realizing the potential of IP as a catalyst for economic development and social and national well-being. In order to deliver an environment in which innovation flourishes to the benefit of all, therefore, a balance needs to be reached between interests of the creators and of society.

4.3.1 Protection effects on technology diffusion

The rise in university IPR protection has increased, with the aim of nurturing a superior interface between HEI and industry in order to increase the social return on R&D. There is concern that IPR protection may impact on the traditional mission of universities; affect the direction of research; stop knowledge flow; and hinder access to publicly funded research results. Intellectual property rights are also known to alter the situation of competitors free-riding on the efforts of others by protecting and providing incentives for innovators to engage in creative activity through legislation (North 2010: 164). This has resulted in university research becoming an important asset because of the very nature of possibly reaping a financial return on a product that has utility. Higher education has therefore increased the focus on research results that translate into intellectual property assets. Engagement by higher education has also increased in relation to the management of technology transfer activities, which include seeking funds for academic research, the licensing of intellectual property, and serving as a liaison for economic development. The complexity of academic research transference to industry for the purpose of commercialization is faced with challenges that require strategic management.

The decision between defense and diffusion is not always an apparent choice to make and the impact of national IPR protection on knowledge diffusion requires careful thought. Protecting an innovation offers the possibility of generating income from the innovation, which can thereafter be reinvested in the further development of technology and the production of complementary goods. The diffusion of technology can encourage multiple industry types in promoting and distributing and possibly accelerating its diffusion further. This becomes useful when a company has insufficient resources to be the sole designer, producer, supplier and marketer of an innovation (Garud 2002: 6). As Schilling (2006: 27) explained, the speed of imitation and the transaction costs of IPR play a major role in deciding the appropriate choice of protection. The decision not to obtain IPR protection on a new technology could result in competitors developing a possibly better version of the technology.

An important basic argument for IPR protection is information disclosure. This statement is supported by Breitwieser (2012: 2), who argued that the option of guarding pertinent information through a patent prompts the innovator to disclose the information to the public, and in doing so contributing to the public stock of knowledge. Once a patent application is unrestricted to the public, challengers can access the information and, depending on the range of patent protection, can further create around the original patent thereby growing long-term competition (Maskus 2000: 3). As espoused by Maskus (2011: 1) and supported by Breitwieser (2012: 2), this builds an inescapable trade-off between static and dynamic competitive concerns. From a static point of assessment the public should gain access to knowledge at a minimal cost, which is close to zero. According for Falvey and Foster (2006: 3), from a dynamic point of opinion a motivation mechanism is vital to inspire innovation. Mechanisms such as IPR protection therefore offer the solution of motivation for research. Intellectual property rights can probably cause distortions through scarce access, however, and may transfer surpluses from clients to innovators. Equally, while weak IPR's satisfy the static aim, namely diffusion, it may not generate the essential motivation for industry to invest in research. Benefit concerns infer that one discovers the prime balance between these two efficiency desires. The outlays due to the provisional control provided by the granting of a patent are therefore reasonable by the requisite of forming motivations for innovation. This infers that patents should only be approved as long as the benefits compensate the costs (Mazzoleni and Nelson 1998: 275).

As discussed above, stringent IPR protection on technology diffusion is vague in theory and will be contingent on a country's circumstances. Intellectual property rights can play a positive role in knowledge diffusion, as patent claim information is available for public consumption. Further innovation is easier when IPR's contribute to the overall stock of knowledge, thereby leading to sustained economic growth.

4.4 Economic development

Governments have become active in encouraging universities to contribute to local economic development. Intellectual property systems have evolved globally with changes made over many past decades. The impact of intellectual property rights on economic development and growth is based on complex variables, which are often found to be challenging, however the effectiveness is largely dependent on each country's individual circumstances. In theory it has been found that stricter systems for the protection of intellectual property could either increase or limit economic growth. Maskus (2000: 1) argued that stronger rights could foster beneficial technical change and increase economic growth, thereby improving development prospects that promote effective and dynamic competition. Nevertheless, Richard (2013: 2) raised uncertainty on whether the TRIP's regime will confidently increase the growth and improve economic development processes. Two main motives were raised for this concern: the first concern was the many elements that affect growth in ways that could dominate the impact of IPR's. These elements include macro-economic stability; market openness; policies for improving the economy's technological infrastructure; and the acquisition of human capital. Secondly, and according to Maskus (2000: 1), the economic theory indicates that IPR's could have many effects on growth, some positive and some negative. Maskus (2000: 1) added however, that in a broad setting of appropriate complementary policies and transparent regulations IPR's could play an important and positive role in promoting economic enrichment, depending on the structure of each country within their system of rights and obligations.

There are important central economic purposes and objectives to any system of intellectual property protection. The most important is the promotion of investment in knowledge creation by establishing exclusive rights to utilize developed technology, including goods and services. Economically valuable information could be obtained by competitors in the absence of IPR's without acknowledgement or compensation to the inventor. Industry partners would take no initiative to invest or collaborate with universities on research activities. This is supported by Falvey and Foster (2006: 6), who argued that the first is to promote investments on innovation by establishing exclusive rights to newly developed technologies, goods and services. In the absence of IPR's, economically valuable information could be appropriated without compensation by competitive rivals. Companies would be less willing to incur the costs of investing in risky research and commercial activities. Thus in economic terms, weak IPR's also create a negative dynamic externality, which fails to overcome the problems of uncertainty in R&D and the risks in competitive appropriation (Hirimuthugodage 2011: 2).

Economic changes have been noted all over the world. To accommodate the changes, developing countries have included restrictive policies within their legislation with respect to controls on trade and industry; foreign investment and technological collaborations; and the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS). According to the United Nations document on Fostering Innovative Entrepreneurship: Challenges and Policy Options (United Nations Economic Commission for Europe 2012: 3), innovation has become the focus as a key long-term factor of economic growth. It has been further reported that innovation studies have indicated an emphasized link between innovation and entrepreneurial effort aimed at the commercialization of research results. Litan, Mitchell and Reedy (2007: 4) suggested that university structures should support all aspects of growth, from the beginning of research to the creation of innovation and all the way until success in commercialization is reached. As highlighted by Boden (2011: 3), innovation and creativity bring competitive advantage to economic growth that is driven by innovation. Investment in research is undertaken with the natural expectation of profiting from new technology and innovations. With changes in local and international landscapes, universities have been forced to change the manner in which they utilize intellectual property assets. Researchers and innovators at universities have come to realize that the sharing of research findings decreases the university's ability to capitalize on income generation.

Universities often use collaboration with industry partners to define their role in economic enrichment. Stanford University played a significantly vital role in the development of Silicon Valley, which produced profound effects on local and regional economies (Chatterji 2013: 3). New companies are continually formed around innovation from university research. To name a few, Hewlett Packard, Intel, Apple, and eBay are all companies formed at Silicon Valley, which emanated from Stanford University's innovation. The Government makes provision for extensive financial support on university research, on condition that institutions conduct exploration that supports and sustains economies (Broad 2013: 6). This creates the motivation for university involvement in economic development. The Government's economic expansion programmes support high-tech development through university/industry relationships as direct contributors to local economies. Roessner (2009: 14) highlighted that industry have acknowledged that collaboration with universities affords varied benefits, such as novel and enhanced products, procedures and services, as well as access to students and graduates with specialized knowledge as interns and future employees for industry. Fontana, Geuna and Matt (2009: 4) concurred that university collaboration with industry also includes the training of employees, assisting local economic development offices, and the retraining of displaced workers. These vital collaborations between university and industry are often unheeded. The academic innovator's main focus is generally on research collaborations that generate tangible goods (Broad 2013: 7).

It must therefore be noted that the commercial worth of knowledge created from university research is only one of an extensive range of outputs that has economic significance. This is supported by Goldstein, Maier and Luger (1995: 27), who maintained that university output leads to a wide range of economic impacts. These include the generation of innovative knowledge and human capital; the transfer of existing know-how (tacit knowledge); technological innovation; capital investment; regional leadership; production of knowledge infrastructure; and impact on the regional milieu. The economic impact is analyzed below:

- **Generation and creation of new knowledge and human capital** – Universities have accepted that the growth of human capital has been a tough objective to isolate from the research function itself (Roessner 2009: 12). This is supported by Ortiz-Fournier *et al*. (2010: 205), when stating that the expansion of human capital is intrinsic in creating new knowledge, as innovators cultivate their own rational skills that occur through activities such as distance learning, industrial extension and community engagement. Similarly, Sampat *et al.* (2011: 377) highlighted specific aspects of university research such as the creation of economically useful scientific and technological information, which increases the efficiency of applied R&D in industry; and the provision of skills or human capital and aiding to create networks of scientific and technological capabilities. The significance of the diverse channels through which these outputs are conveyed to industry has transformed over time. This includes the employment of student interns; a consulting relationship between the university and industry; publications; conference presentations; informal interactions with industry researchers; start-up companies; and the licensing of patents. Recent studies have indicated that there is agreement between universities and industry that the primary channel along which learning occurs is through publications, conferences and informal information exchange (Cohen, Nelson and Walsh 2003: 22; Agrawal and Henderson 2002: 55).

- **Transfer of existing know-how (tacit knowledge)** - Knowledge and technology transfer focus on the application of existing knowledge to solve problems for the improvement of existing products and processes; and on the creation of economically useful scientific information which assists in the upsurge of efficiency for applied R&D in industry. Kitagawa (2005: 67) added that university/industry collaboration at different spatial levels enables the flow of knowledge from universities to industry and society. University knowledge workers contribute to the productivity of the local economy by introducing new curricula and the continual development of courses for the needs of the local economy.

- **Technological innovation** – The creation of technological innovation arising from university research results in patents, licensing, and the formation of start-up companies. New innovation produces equipment and instrumentation used in production by industry. The rise of technological leadership in the post-war era was attributed to the strength of research universities as the most important economic institutions of the twentieth century (Atkinson and Blanpied 2008: 32).

- **Capital investment** - Intellectual capital is progressively being documented as the most important asset. Universities are the main source of this type of capital investment, on which industry thrives. The considerable value of these assets is because of its novelty, uniqueness and utility. Examples of such are patents for innovations, trademarks, industrial designs, utility models, copyright, know-how, and trade secrets. Direct business-related capital investments include the establishment of research and advanced technology parks (Goldstein 2010: 93).

- **Regional leadership** - A direct development activity of universities is the participation in regional leadership. Economic historians agree that the rise of the American technological and economic leadership in the post-war era was from the strength of research of the American university system (Sampat, Mowery and Ziedonis 2011: 1375). Many countries viewed university/industry collaboration as a competitive advantage and pursued a duplication of the underlying conditions associated with these trends (Neal, Smith and McCormick 2008: 22). Trends set by Stanford University's success in innovation commercialization has been evident and universities globally have benefitted from their experience. Universities play a double role in regional leadership by providing technical expertise and moral authority (Goldstein 2010: 89).

- **Production of knowledge infrastructure and influence on regional milieu** - The design of prototypes for novel products and processes by universities impacts positively on industry usage. Sampat, Mowery and Ziedonis (2011: 1377) stated that the importance of the diverse channels through which these outputs are transferred to industry has changed over time. The creation of knowledge infrastructure and a favourable milieu relating to the teaching and research functions of universities is one channel, since they provide the necessary framework. This combined availability of knowledge in the form of books and research experience facilitates the flow between universities and industry, thereby enhancing the productivity of a region (Goldstein 2010: 88). The regional milieu that has a high-technology base and funding in the form of grants and venture capital therefore enhances industry growth (Fini *et al.* 2011: 117; Shane and Stuart 2002: 162).

It can therefore be argued that the function of universities within the innovation system has broadened with an increased demand for the economic applicability of research. There is an expectation that universities will directly contribute to the innovation system in national economies (Organization for Economic Co-operation and Development 2013: 5). This was further reinforced by the OECD (2013: 4), which stated that, “universities and other higher education institutions are key elements in the science system in all European Union countries”. Furthermore, Atkinson and Blanpied (2008: 47) stated that one cannot afford to assume that the public understands and appreciates the role played by universities in the success of the essential goals of society. Records over the past 60 years, however, advocate that universities continue to compete successfully in the world market for knowledge. Although the integrated roles of universities hinge heavily upon research, the skill to attract funds for research is still essential to university operations (Clark 2006: 8). A further challenge to universities is the reliance of their budgets on the changing of governors and legislatures. As explained by Atkinson and Blandpied (2008: 33), although leading state universities originate the majority of research budgets from federal grants, funding from the Government remains the base of their research programmes. This is further elaborated on by Baxter (2011: 18), in that as much as the sitting State governor and legislature may identify the significance of research and innovation development of a university, their replacements may decide that a major decline in university budgets can do little harm when confronted with budget shortfalls. It is never understood that reconstructing a diminished educational institution takes many years to accomplish (Atkinson and Blandpied 2008: 34).

4.4.1 Impact of blue-sky research on economic growth

Blue sky research is scientific research in areas where ‘real-world’ applications are not instantly apparent. It is defined by Bell (2005: 33) as “research without a clear goal" and "curiosity-driven science". It is used interchangeably with the term "basic research" (Linden 2008: 22). Advocates of this mode of science have argued that surprising scientific innovations are often valued more than the results of agenda-driven research. Discoveries often come from blue-sky research. According to Borysiewicz (2012: 1) a possible explanation for this is that innovations making large economic contributions tend to result from fundamental (blue-sky) research, and not from applied (or 'near-market') research. According to Henderson (2002: 6) due to the inherently tentative return on investment, blue-sky innovations are politically and commercially slower in attracting funds when compared with the more reliable, profitable or practical innovation. Be it applied or basic research, the impact that innovation has on economic growth is still a priority in every country. University innovation plays an enormous role in governmental priority, and they are therefore seen as innovation drivers. The Government plays a key role in ensuring that entrepreneurs, investors and innovators have an enabling environment by funding blue-sky research, new discoveries and innovation; improving the interface between HEI’s and industry; and by creating incentives for the commercialization of research.

As explained by Borysiewicz (2012: 2), should a pharmaceutical company contract a university to improve the efficacy of a precise drug then the effect will be economically and socially useful but limited, and perhaps more effectively done within the company. He explains, however, that a more fundamental task such as identifying a new target molecule is better suited to a large multi-disciplinary research-intensive university laboratory. In this instance, the university researcher is focused and sets out, from a perspective of curiosity, to learn how a fundamental biological process works; the results thereof can be limitless and transformative. An example of this led to the discovery of the structure of DNA, which has had an impact on everyone's lives. This is an example of the economic benefit of a by-product which generated billions of Euros. The two examples are connected, in that today's pharmaceutical research relies on yesterday's 'blue-sky' research (Connell 2010: 17). While the pipeline period of results on a discovery from one format to the other may be a long period of time, it is apparent that with continued research the pipeline should not be halted.

Basic research undertaken today could be applied in the future by generations yet to come. Lord Porter insisted that essential research and applied research are one and the same, "There are two types of research: applied, and not-yet-applied". The Government, the public and private investors need to realize that investment in university innovation has the ability to shape innovation for increased economic growth. One such example is the formation of a company called Cambridge Consultants by a pair of Cambridge graduates in 1960, which started the growth of a cluster of high-tech companies around the university. This was described as the 'Cambridge Phenomenon'. This started the process by which tactical scientists set up companies to yield advantage of the proximity to a great research university, so allowing the cluster to grow to other companies doing similar things. This cluster has grown to more than 1800 high-tech companies, including 'spin-outs' from university laboratories to branches of multinational companies such as Microsoft.

4.5 Commercialization route

Results of research conducted within university laboratories have long been important sources of technology commercialized by industry partners. An important decision that IP&TTO's and innovators are faced with is whether to license a technology or to create a start-up firm to commercialize. A key effort in the contribution of universities to regional growth is on technology transfer, but mostly patenting, licensing and spin-offs. Some of the typical routes for the commercialization of innovation are the direct sale of innovation; research collaboration; the open source route; and licensing or a transfer of IP to an existing or spin-out (also referred as spin-off) company.

4.5.1 Typical routes for commercialization

The various options available for the commercialization of university innovation are discussed below:

- **Direct sale** - There are instances where a product or service can be offered directly from a university laboratory or department without incurring high capital costs. In these instances, the sale will be directly guided by the institution's policy. Product liability is a potential risk for the institution and should be considered at all times.

- **Technology transfer broker** – A technology transfer broker is a convenient route for assistance with the commercialization process (Hedge 2010: 11). An agreement will exist between the IP owner and the broker, clearly reflecting the share of the royalty distribution between both parties. Some of the services offered by the broker include that the costs involved in the commercialization process are borne by the broker; and a technology transfer broker normally has a network of probable licensees with extensive knowledge in the field of technology licensing.

- **Research collaboration –** Intellectual property often stems from research collaboration with an industry partner. In such instances the specific IP may be exchanged for a research grant. A royalty-free license is afforded to a private entity in exchange for research funding. Innovators are eligible for benefit-sharing of non-monetary benefits, which is normally dictated by the institutional research policy.

- **Open source route -** Software is a typical example of IP delivered through an open source model. The source code is provided and open for use and adaptation. Licenses for usage are applied but are usually royalty-free, although if sold commercially clauses to share income can be included. The open source route is considered for dissemination of information on new technologies or improvements to existing technologies through manuals and practical training programmes. Manuals are sold and training is provided to generate income from this type of research output (Southern African Research and Innovation Management Association 2013: 23).

- **Licensing** - A license agreement is a contract between an IPR owner (licensor) and an entity authorized to use such rights (licensee), in exchange for an agreed payment. Licensing agreements allow a university to generate revenue from a company in return for the use of an innovation. This revenue of upfront fees at the time of issue of the agreement, or from annual royalty payments, is subject to the commercial success of the innovation (Feldman *et al.* 2002: 113). The benefits of a license allow the innovator and the organization to capitalize on the technology, whilst allowing the scientist to focus on potential business issues (Lockett *et al.* 2005: 988). The licensor retains ownership of the IP rights. An in-depth discussion on the types licensing follows.

4.5.2 Types of licensing

The licensing of technology for diffusion is recognized as being complex when compared with other types of commercialization channels. Maskus (2004: 6) argued that the reason relates to the large diversity of licensing agreements that are available. For example licenses exist within a firm, joint venture or amid unaffiliated firms. A license may be offered in many different forms, such as at a fixed fee, a franchise fee, a royalty schedule or a share of the profits. Falvey and Foster (2006: 33) advised that rights may be offered to produce and/or to dispense the product of a licensee for a given period of time, within a specific geographical territory.

A license agreement defines the terms and validity of the contract. This usually includes the duration of the license; the market and area; geographical territory; and the field of use in which the licensee can utilize or sell the product. It also clearly defines whether or not sub-licenses are permitted, and the nature and amount of upfront fees and royalty distribution of the income that is generated. The agreement normally outlines whether or not the licensor has the rights to any further improvements established by the licensee (Hedge 2010: 9).

There are three types of licenses, as highlighted by Goldfarb (2011: 8):

- A **non-exclusive** license is when the licensor may hand out multiple licenses. Non-exclusive licenses may be given when the technology does not require significant investment in development or when the licensees do not compete on the basis of the licensed technology (Cervantes 2011: 9). Examples can include software licensed non-exclusively.
- An **exclusive** license is when the licensee is the only party who has the right to use the IP, which also excludes even the licensor from commercial use of the

specific IP in question (Cervantes 2011: 8). This provides the licensee with a major competitive advantage with potential for a great financial profit, so that the licensee has an incentive and is encouraged to commercialize the technology.

- A **sole license** is a type of exclusive license with an exception. The licensor is entitled to continue using the licensed subject within the territory of exclusivity (Trans Legal Group 2015: 1). Unlike a typical exclusive license, the licensor generally retains the right to use the IP. The instant that a licensor grants a sole license, the licensor retains the right to commercialize the technology in addition to giving a license to the licensee. This clearly means that only the licensor and the licensee have the rights to use the said IP.

Licensees more often request exclusive licenses as they offer more protection for the necessary development to be conducted prior to the innovation becoming a marketable product. Cervantes (2011: 13) reported that exclusive licenses tend to limit the diffusion of technology. An OECD (2013: 8) report stated, however, that the mix of exclusive and non-exclusive licenses granted by public research institutions is fairly balanced, and that exclusivity is often granted with restrictions on the licensee side. Furthermore, Ligget (2012: 23) indicated that research institutions often include clauses in license agreements to protect the public interest from access to future research and development. Additionally, included in a licensing agreement is the sincere commitment to exploit the innovation on the part of the licensee, particularly in instances where the license is exclusive. It is therefore of vital importance that the agreed milestones are clearly set in order to ensure that commercialization is encouraged. Measures within licensing agreements further ensure that the licensed technology is not simply utilized as a defensive licensing mechanism to block competitors.

A rapid growth is noted in the licensing of university innovations to industry. As previously mentioned, the role of licensing is a complex route and difficult to characterize. Licensing can differ in terms of the type of rights being transferred, for example distribution rights, production rights, and geographical territory rights. Evidence of licensing growth marks the success of the transfer of innovation from university to industry. Despite the evidence of growth, Thursby and Thursby (2010: 160) reported on concerns that universities are moving towards applied research in an effort to capture increased licensing income.

4.5.2.1 Factors influencing decisions to licence

There are various factors that influence a university's decision to license an innovation. Tilling (2010: 33) highlighted that universities are greatly predisposed by two major determinants:

- ❑ The type of licensing that is likely to lead to rapid commercialization. Some of the crucial factors that universities focus on are the types of technology in question; the innovation stage of development; possible market potential; the estimated profit margin; apparent risk; strength of the patent; and the probable cost of conveying a product to market.

- ❑ The type of licensing that is in the best interests of the public. The license terms are drawn up so as to adequately safeguard the interests of the public, ensuring quality and a market-related price for the product.

As explained by Stoner (2011: 19), patents which are wide in scope could be used by different industry types and are therefore licensed non-exclusively, which enables greater diffusion. Patents that are basic and form the building blocks of new technology are most likely to be licensed non-exclusively. An exclusive license is utilized to protect the market of a particular industry type, while allowing universities to identify different fields of use that guarantees the public utilization of technology in all possible fields of the market (Shotwell 2012: 8).

Stanford University's Cohen-Boyer patent is a case of a basic patent licensed to all companies with the possibility of utility. Edmond (2011: 7) advised that an exclusive license indicates that none other than the licensee can exploit the relevant IPR’s. Contracting parties therefore need to consider the degree of exclusivity to be granted, at an early stage of the process. Should a licensor require to continue with the activity covered by the IP (for example a university licensor may want to continue with further research), this needs to be clearly indicated on the license agreement and subject to the points expressly agreed upon. Edmond (2011: 9) further explained that a non-exclusive license allows the licensor to license the same IPR to more than one licensee at any given time. Non-exclusive licensing is selected by universities when a technology can be utilized to foster product development in many fields of use. An example of this arises when the technology is of benefit to the public and becomes a norm for industry standards; the university then elects to make it accessible to as many interested parties as possible (Thorne 2013: 2). It can therefore be said that differing types of market interest ultimately drive the decision to license on an exclusive or non-exclusive basis. The capital investment required to develop products, including the value and risk associated with new innovation, is a factor to be considered when determining which type of suitable licensing agreements is appropriate. Theoretical considerations also suggest that licensing is favoured over the other channels of technology transfer where IPR’s are stronger in the country of innovation (Falvey and Foster 2006: 30).

Several risks facing a university in its licensing decision to commercialize have been identified. The licensing of a technology with the intent of shelving the innovation due to competitive considerations is a common occurrence. An example is that of technology that competes with an existing technology, or a firm simply licenses the technology to prevent competitors from licensing (Thursby 2009: 112). This type of licensing is commonly known as defensive licensing.

The relationship between licensing and IPR protection suggests that countries with stronger IPR protection increase licensing, while countries with a lower level of IPR protection has reduced licensing agreements (Baxter 2011: 23). This is argued because countries with the lowest levels of IPR protection generally have the weakest imitative ability. Higher levels of IPR strength in countries therefore slightly reduces the risk of counterfeit products, and would therefore increase the control of the licensor (Maskus 2000: 2). It is suggested that the effect of patents rights is likely to dominate and lead to lower licensing, however evidence indicates that stronger IPR protection has a positive impact on licensing.

4.5.2.2 Factors influencing commercialization route

The best channel for the transfer of technology to the marketplace can be complex, as this is influenced by many factors. Cervantes (2011: 9) believed that the answer would depend on the consideration of various factors, such as the specific technology in question; market analysis; the skills set of staff and researchers involved in the specific innovation; access to venture capital; and finally, the control, mission and goal of the institution.

- **Specific technology in question -** The optimal route for commercialization depends on the nature of the technology itself. The decision depends on the type of technology in question and the environment for which it is meant. Forming a start-up makes commercial sense, although it has been considered as a complex process. Complexities involve trademark registration for a new start-up company. production costs and the quality of production are also important factors.

- **Market analysis** - The potential market for an innovation is an important factor in the choice of commercialization path. The route for commercialization requires an in-depth market analysis. Kamariah *et al*. (2012: 683) suggested that the first step would be to explore the different products and service concepts that the technology could enable, as well as the different target markets. The investigation of each market area would entail outlining the product description together with analyzing the strengths, weaknesses, opportunities and threats (SWOT analysis). In some instances markets controlled by large companies create difficult competition. A realistic valuation of the innovation is important. A calculation on the size and structure of the market is crucial to the decision of the commercialization route.

- **Skills set required for innovation -** The route is meaningless without the correct team to develop and implement the commercialization process. In some instances it may be important for the innovator to identify and recruit a technical team with the desired skills (Ismail, Majid and Omar 2011: 84). Innovators must recognize their skills and limitations and seek the right expertise required. Often new innovations do not succeed as a result of poor management skills. It is found that innovators believe that their strengths as researchers can be applied to that of company management.

- **Access to venture capital -** The positive effect of selecting a venture capitalist to fund an innovation is the ability to fund the initial capital and the second round of funding when required, or to deal with unexpected complications (Yaacob 2011: 142). The importance of venture capital is that it does not limit the ability of the company to grow, which creates significant confidence in the innovation. What must be considered, however, is that some venture capitalists only specialize in a specific area and at a certain stage of development of the technology.

- **Control, mission and goals of an institution -** The commercialization route is also guided by the mission and goal of the university. To an extent, commercialization may result in giving up some measure of control over the innovation (Commercialization Handbook n.d.: 38). This process is often found as a collaboration between people with common objectives, but different motives. Most investors are focused on market opportunity and financial rewards more than the actual innovation itself.

Whilst a wide range of technology is commercialized via start-up companies, others may be integrated into an existing company's R&D strategy with the appropriate business capacity. Goldfarb (2011: 9) suggested that the choice of licensee is a matter of identifying the best development environment, and subsequently resolving whether a company is best suited for commercialization or subsequent licensing to a third party.
An established firm may prove a more viable option than a new start-up company that runs the risk of survival on a single new commercial application. Risks associated with new start-up companies are outright organizational failure due to poor management, or being unable to obtain the resources required for development and sustainability (Goldfarb 2011: 9). The preference of exploiting an innovation by licensing to an established company therefore proves to be a less risky option. Cervantes (2011: 9) reported that Governments and university managers tend to favour start-up companies, as opposed to licensing strategies. A possible reason for this is the rise in Government funded ventures that aim to promote the establishment of new start-up companies and business incubators. Eesley and Miller (2012: 15) explained that university incubators are research incubators or knowledge centers for new business and products, as well as a place where start-up companies find space to work and for colleagues to shares ideas and facilities. Although technology may change, the objective remains the same: to provide industry with access to new research by offering researchers an opportunity to test their ideas in the 'real world', that is, in the business world. University-based start-up companies have the added advantage of creating job opportunities, as opposed to licensing to an existing company.

Ismail, Majid and Omar (2011: 91) declared that universities which practice the intense selection of patenting and firm formation run the risk of discouraging commercial activity. Conversely, being less stringent may encourage innovators to come forth with more disclosures for patents. The success in commercialization not only generates monetary returns, but also contributes to the prestige of the university by emphasizing their research capabilities.

4.6 University-industry collaboration

Traditionally, industry engagement with universities was to identify, train and recruit future employees. As economies evolved industry required access to cutting-edge knowledge and innovation from university research, which triggered collaboration. Historically the Government provided funds for R&D, however with declining subsidies then university researchers had no alternative but to seek sponsorships from industry partners. This led to research engagement between universities and industry, thereby creating partnerships which enabled sustained growth in specialized areas. Often this resulted in industry relying on university researchers for cutting-edge innovation, while researchers gained exposure as specialists in the field through increased external engagement.

Stemming from revised IPR Acts globally, it was found that the IP&TTO's at universities have increasingly assisted industry in meeting the demand for growth through collaboration. The acknowledgment of mutual benefits between universities and industry enhanced the joint venture concept. In the past industry partners had insisted that funding was only available in return for ownership, research secrecy and exclusive rights to the IP that was generated. As reported by Baxter (2011: 17), the restriction of knowledge dissemination was therefore previously viewed as compromising the academic ethical position.

Innovation and economic growth have become enhanced by the combined effort of universities and industry working in tandem to increase the technological output from research activities. In order to achieve increased economic development, the collaboration between universities and industry had to remain mutually beneficial. This is supported by Guimon (2011: 78), who highlighted that collaboration is critical for skills development (education and training); the generation and adoption of knowledge (innovation and technology transfer); and the promotion of entrepreneurship (start-ups and spin-outs). This type of collaborative relationship is a critical component of efficient national innovation systems. While universities continue their role in education, technology absorption, adaptation and diffusion of knowledge (Weiping 2010: 38), they are also seen as important drivers of economic development. By expanding the relevance of research results from R&D outcomes, universities are further increasing the mobility of labour between the public and private sectors (Guimon 2013: 1). Universities and industry are therefore finding it increasingly beneficial to collaborate.

Likewise, industry is progressively adopting methods to access and integrate external sources of knowledge, with a keen interest to collaborate with universities. Beyond the teaching-research-entrepreneurial nexus some advocate shifting the focus towards creating developmental universities to collaborate with industry, although not necessarily with a focus on profit-making but with the broader purpose of contributing to social and economic development (Brundenius, Lundvall and Sutz 2009: 311). This is further advocated by Guimon (2013: 3), who stated that the mission of universities has moved beyond the tradition of teaching and research and closer toward a ‘third mission’ related to better addressing the needs of industry and contributing directly to social economic evolution and development. Relationships between universities and industries are built on several factors. Some of the contributing factors that encourage and enable collaboration are Government policies; funding of institutions’ interests; sharing of knowledge and expertise; and IPR’s.

Universities develop and manage the existing relationships with public and private entities by launching new joint projects. Industry too has established networks at universities known as 'Centres of Excellence' to provide new ideas, expertise and patent rights. Thus, industry finds that universities play a crucial role in developing new knowledge that companies turn into marketable products. Exploring external engagement by academic researchers is of a high priority and interest to IP&TTO managers at universities. Governments, funding agencies and universities have made exhaustive efforts to enhance academic engagement with industry. Commercialization is considered the prime reason for this engagement as the impact establishes instant, measurable market recognition for the output of academic research (Markman, Siegel and Wright 2008: 1401).

4.6.1 Motivation for collaboration

Universities and industry are organizations with a difference in culture, and are therefore driven by different incentive systems. Universities are driven to educate, to conduct research and to create new knowledge, while industry is focused on strengthening competitive advantage by adapting externally generated knowledge from research organizations such as universities (Laursen and Slater 2014: 871). Success in university/industry collaboration is further motivated by incentives which are captured in Table 4.1.

Table 4.1 Incentive for university-industry collaboration (adapted from Piacentini 2013).

University offer to industry	Industry offer to university
Fundamental research and the enhancement of own research.	Access to world-class and important problems.
High profile personnel and skilled workers.	Access to other activities in the innovation cycle (development, engineering, manufacturing, etc.).
Access to consultants.	Market awareness.
Access to tacit knowledge.	Enriching teaching programmes.
New ideas and business opportunities.	Job opportunities.
Recruitment of graduates.	Funding opportunities.
Leveraging of federal funds.	
Costs - lower overheads.	

4.6.1.1 University offer to industry

Industry outlines various reasons for collaborating with universities, with the most common falling into three broad categories: reduced risk and cost; access to new ideas from research results; and the development of skills, capability and profile (Baxter 2011: 17). This is supported by Piacentini (2013: 6), who stated that the motivation for industry to collaborate with universities includes gaining access to technological knowledge (including patents and tacit knowledge); tapping into a pool of skilled workers; and providing training to existing and future employees. As reflected in Table 4.1, a discussion based on the benefits of what universities offer to industry follows below:

- **Fundamental research and enhancement of research -** Industry benefits from university research results. Industry research is enhanced by the expertise of university researchers. Students undertake experiments for industrial research, which saves industry time and the added cost for experimentation and testing.

- **High profile personnel and skilled workers -** Industry has access to high profile researchers at universities, some of whom have publication output and patents. Universities provide a pool of graduates and undergraduate students that industry may access for recruitment. Universities also offer training for industry workers.

- **Access to consultants -** University researchers with expertise and in-depth knowledge in specific fields offer consultancy services to industry. Jones and Stephen (2012: 4) asserted that industry scientists involved in breakthrough discoveries maintain close alliances with university researchers in order to gain a better understanding of the science that underscores the discovery.

- **Access to tacit knowledge -** The motivation for industry to collaborate with universities is increased by gaining access to complementary technological knowledge (including patents and tacit knowledge).

- **New ideas and business opportunities -** Industry gains access to research results from university laboratories, which can result in new business opportunities. Industry often sponsors or gifts scientific equipment to the university for research. Although this is referred to as 'gifting', companies have an expectation of the university repaying the generosity by communicating leading-edge research outcomes related to the use of the equipment. This gives companies an edge in innovation, as they capitalize on research results that create potentially profitable products (Baxter 2011: 19).

- **Recruitment of graduates -** A common practice is that universities provide industry with appropriately qualified students for recruitment purposes. Arising from collaborations with universities, industry partners can be assured of the students' knowledge potential.

- **Leveraging of federal funds -** By engaging with universities industry gains access to Government funding allocated to universities for research and development.

- **Costs and lower overheads -** Industry benefits from a cost perspective by gaining access to university facilities and equipment. Industry partners reduce risks by sharing the cost of R&D while gaining access to public funds from the Government. Universities have research infrastructures that industry requires and from which they can benefit. A cost effective benefit is to contract research to universities with existing research infrastructure in place, instead of industry duplicating this at an additional cost (Jones and Stephen 2012: 6).

4.6.1.2 Industry offer to university

As reflected in Table 4.1 and supported by Koschatzky and Stahlecker (2010: 96), the typical motivation for universities to collaborate with industry includes the improvement of teaching; access to funding; reputation enhancement; and access to empirical data from industry. The benefits of the industry offer to universities are discussed below:

- **Access to cutting-edge problems -** Industry has access to real-life problems which would be shared with the university in the hope of a collaborative effort in finding solutions. This would therefore expose students at universities to valuable knowledge and also to industrial job opportunities with possible cutting-edge solutions.
- **Access to activities in the innovation cycle -** University researchers receive critical workforce training that supplements theoretical courses. Workforce training is increasingly accepted as a critical component of education in the knowledge-based economy.
- **Market awareness -** University researchers gain access to activities beyond the research performed at laboratories. Researchers observe the process of a product produced within industry in preparation for the market readiness.

- **Enriching teaching programmes -** The university gains access to an entirely different type of culture, thinking and learning about the marketplace that impacts on the teaching programmes. University researchers field-test applications of their research and gain new and valuable insight from industry for the practical application of their research.

- **Job opportunities -** A common practice for industry is to recruit and offer job opportunities to students from universities with which industry has already collaborated. This measure assures industry of the level of experience and potential knowledge that the student possesses.

- **Funding opportunity -** Industry partners assist universities with research funds. Academics seek collaboration with industry to secure funds for graduate students and lab equipment; to supplement research; to field-test the application of research; and to gain new insights on research.

D'Estea *et al*. (2013: 21) identified university/industry linkage as a good predictor of effective technology transfer. This is supported by Feldman and Desrochers (2004: 120) and Jong (2006: 281), who contended that universities with established collaborative research experiences with industry easily identify opportunities with commercial potential.

Long-term collaborations are strategic and open-ended, providing a multi-faceted platform for industry to develop stronger innovative capacity, thereby building upon the capabilities, methods and tools of universities (Koschatzky and Stahlecker 2010: 3). This is supported by Landry *et al.* (2007: 569), who stated that most productive collaborations are strategic and long-term with a two-way interchange of knowledge diffusion. A shared research vision, established concrete ties, trust and a two-way interchange of knowledge are the benefits that work to bridge the cultural divide between academia and industry.

4.6.2 Impact of university - industry collaboration

Government agencies, industry and universities have made determined efforts to escalate collaboration, for reasons that range from generating societal legitimacy for publicly subsidized research to stimulating economic activity in the generation of income for universities. The importance of university/industry engagement and the impact thereof is discussed below:

- **University benefits -** Collaboration with industry is strategically planned with a focus on benefits accruing to the university. Universities often attract industrial partnerships because of the prospective financial rewards of patents and licenses that stem from the commercialization of academic research (Jones and Stephen 2012: 2). This provides a means by which universities generate income to supplement depleting government subsidies. Patents generated through industry-sponsored research are sometimes shared between the company and the university. Jones and Stephen (2012: 2) stated that universities utilize the revenue generated from patents to support activities that are not market-oriented, such as the teaching mission of institutions.

  Additionally, Baxter (2011: 17) highlighted that university researchers may benefit through access to cutting-edge scientific equipment within industry that is not always available in university laboratories for additional research. University collaboration with industry enhances the university's prestige, a component used to attract top students and to establish legitimacy and prominence for acquiring public funds. Industry-funded research and internships further enhance graduate education by providing faculty and students with an understanding of industrial requirements and knowledge of real-life problems. Thus, increased awareness enhances academic researchers' understanding of challenges facing industry by exposing the university faculty to industrial concerns and possible new industrial approaches to research.

- **Industry benefits -** University researchers assist industry partners by stimulating internal projects with current research for the design and expansion of innovative processes and potential products. Leading-edge research gives companies a competitive edge as it decreases the time taken to move potential products from the laboratory to the market, which strengthens economic competition. A company's reputation is enhanced by sponsorship and association with universities. University researchers contribute to industry scientists by solving design and technical problems. Frequently, company employees learn new research techniques from university researchers. Additionally, joint publications between university and industry partners are used as a public relations tool to add value and prestige to companies.

  Concrete benefits emerge when companies become involved with academic research and gain access to new ideas (Federica, Rosli and Yip 2014: 7). This results in trade secrets, leading to potentially profitable output in products. Furthermore, should the university develop a patent from industry sponsored funds then the company often gains the first option to license the product, with the opportunity of becoming an industry leader. Ultimately research collaboration strengthens the generation of innovative products into profitable lines. Industry experiences low technological capability in innovation, which increases the demand for the external knowledge that universities can provide. In the words of Wunsch-Vincent (2012: 97), "absent its own R&D capacity, the private sector cannot 'absorb' what is done in public research". Universities seek to form strategic collaborations with industry in the hope of obtaining funds. High investment collaborations are appealing to universities; these are the result of foundational work over a number of years where universities have capabilities that meet industry requirements by providing tangible benefits to industry partners (Chaguturu 2014: 8). Partnerships between university and industry grant exclusive rights in the use of technology arising from university research, which allows industry to stay ahead of their competitors (Datta 2011: 12). Additionally, Welsh *et al.* (2008: 8) stated that university technology transfer is known to be beneficial for the reputation and the innovative ability of any industry partner. This is supported by Bansi (2012: 61), who declared that it can be concluded that collaboration forms an important role in the transfer of research results to industry.

- **Social benefits -** New technology and innovative products are the social benefits from the results of university/industry collaboration. According to Jones and Stephen (2012: 23) these applications include improved medical devices, techniques and therapy; energy efficient development; and innovative electronic technologies such as computers, software and DVD players. University/industry engagement often results in new companies, thereby enhancing the growth of new industries with the added social benefit of job creation. Importantly, and as stated by Federica, Rosli and Yip (2014: 7), the social benefits relating to networking and gaining recognition concern the distributive aspect of knowledge. Strategic benefits relating to further opportunities arise through collaboration, which often have an eventual positive effect.

Globally universities play a leading role in advancing the limits of science and technology, and in transforming industry. Silicon Valley is known as the typical example of university research that established new industries (Kruss 2009: 1). Researchers are sought by universities to secure additional financial support from collaborative industry partners. Furthermore, universities use technology transfer as an added method to gain financial support from external sources. It has been noted that university researchers engaging with industry partners have a higher research performance rate (Fabrizio and Di Minin 2008: 929). Literature reveals that closer relationships with industry partners leads to research with a higher social impact, as companies are better able to monitor the needs of society than are universities. This is complimented by Datta (2011: 13) who stated that the transfer of funded research promotes a rapid rate of diffusion, which is utilized by the funding industry at a relatively low cost.

It is found that sound university/industry collaboration enhances the transfer of innovation to a faster rate of diffusion (Welsh *et al*. 2008: 1861). The process of marketing an innovation leads to an increase in patent activity, signalling a mechanism to build research reputation for the increased attention of industry partners (Datta 2011: 13). This can achieve long-lasting engagement between industry and universities, supported by incremental technology transfer activities. Having examined the economic importance of intellectual property, one understands more clearly the positive impact that collaboration has on innovation diffusion and commercialization.

4.6.3 Challenges facing university-industry collaboration

Challenges within university/industry partnerships exist, despite the advantages. Bowie (2014: 12) suggested that universities have become "caught between two of its compelling interests". This is due to sharing research results for review and validation to publish, without regard for the commercial benefit or protecting the results for further exploitation. Challenges emerge as industry seeks saleable products, while the academic focuses on output and publication. This often becomes a contentious issue during university/industry collaborations (Cane 2013: 19). Most university policies accommodate publication delays for up to six months, allowing researchers and sponsors to file a patent application. This six month delay period is known as an embargo, which is perceived as a solution. Industry partners require approval of the journal article prior to publication, which results in publication delays.

Industry partners do not allow researchers to include pertinent methodology details in published work of the results produced from sponsored funds (Broad 2013: 2). Industry has argued that the methods used to conduct the research constitute the company’s trade secret and must be protected. This creates problems for academics who need to publish in order to generate additional research funds. Industry prefers that researchers do not publish the results from sponsored work, as their attention lies on market focus. Trade secrets are utilized by companies to protect innovation that emerges from corporate-funded projects. Broad (2013: 3) reported that this is contrary to dissemination practice at universities, as post-doctoral fellows and graduate students opt to publish results as soon as a discovery is made. Commercial enterprises are more competitive than academic interests, as an industry's requirement is to secure its niche market for new products to be launched.

Naturally, barriers exists within all forms of partnerships, some of which are highlighted below:

- An inherent mismatch exists between the research orientations of firms and universities. Collaboration is costly and the returns only accrue in the medium- to long-term future. The focus of industry is to seek contributions to current business lines with quick commercial results (Guimon 2013: 4), while the university's focus is on basic research and publications.

- In terms of output, firms are usually interested in how quickly new products can be obtained, and additionally to delay publications to avoid disclosure of information. University researchers, by contrast, are typically motivated to publish results as quickly as possible (Datta 2011: 12). Universities seek long-term partnerships to conduct frontier research.

- An industry concern is secrecy, the misalignment of expectations of IP rights, and generating a profit. Guimon (2013: 5) posited that agreements must be established in a commercially timely manner that ensures the ability to commercialize with appropriate returns.

- Difficulty in negotiations from a lack of information, locating correct contact persons, and transaction costs in finding the right partner.

- Both partners' mission and goals must be supported, a concept that is often neglected. A conflict with the mission or goal results in failed collaboration with negative effects. As indicated in Table 4.2 below, a conflict of mission and differing goals can arise in a single project, which is not conducive to a sustainable, long-term collaboration.

Table 4.2 Difference in focus between university and industry (adapted from Piacentini 2013).

Industry	University
Market driven	Advantage of knowledge
Focus on return on investment	Academic freedom
Extremely cost conscious	Publication of results
Oriented to profit	Education of students
Particularly sensitive to timing	Relaxed timeframe and milestones

To ensure success arising from university/industry collaboration, a report of the Joint Project of the U.S. National Council of University Research Administrators and the Industrial Research Institute collectively recommended the following guiding principles for university-industry endeavors (National Council of University Research Administrators 2006: 1):

- Successful university/industry collaboration should support the mission of each partner. Any collaboration resulting in conflict with the mission of either partner will ultimately fail.

- Institutional practices and national resources should focus on fostering appropriate long-term partnerships between universities and industry.

- Universities and industry should both focus on the benefits that will result from collaborations by rationalizing negotiations to warrant conducting the research timeously, and further expansion of research findings.

A benefit to both universities and industry is the reduction of time wasted on non-value-added activity. Industry therefore seeks to identify specific universities to develop stronger and more rewarding collaboration. Universities seek to become a 'strategic partner' in order to gain access to additional resources and benefits. Universities will not want to run the risk of not being selected as a core strategic partner. The time and effort towards agreement negotiation can lead to significant frustrations for administrators and researchers alike. Universities and industry have differing perspectives and missions for the intended research results. These factors can lead to protracted negotiations.

The barriers and guidelines discussed are relevant to all university and industry types, although collaboration differs by objectives, scope and institutional arrangements. The challenge for universities are most often to produce research results which can be converted into economic returns through patents, spin-offs or other means, for example by consulting and contracting. These challenges are sometimes due to financial constraints and infrastructure. According to Guimon (2013: 4), industry with low technological capability and a low interest in technological innovation increases the demand for external knowledge that universities could provide, to the mutual benefit of university/industry collaboration.

4.7 Conclusion

"It is individuals who understand both worlds – academia and business – that are the driving force behind successful partnerships," Begg (2014: 9). No academic institution or industry has the necessary financial and technical capabilities collectively to independently take an innovation all the way to market, hence the importance of university/industry engagement. Research collaboration has been in existence in various forms for many decades, even though the engagement remains complex, and the difference in value, mission and goal always conflicts. Due to the strategic relevance of university - industry partnerships it may be wiser to focus attentively, as this format seems to provide one of the main sources of innovation in the market today.

Chapter five will cover higher education and intellectual property in South Africa.

Chapter 5

HIGHER EDUCATION AND INTELLECTUAL PROPERTY IN SOUTH AFRICA

5.1 Introduction

The South African higher education system has been the focus of widespread analysis and reflection over the last two decades. The stimulus for this has been both global and domestic. Publicly financed, higher education institutions form part of the largest concentration of skills and personnel in the area of science and technology in South Africa; concomitantly there are robust prospects for the growth of patentable innovation (Sibanda 2008: 113). The South African higher education system was restructured through the merger process involving universities and technikons during the period from 2002 to 2006. As a result of the restructuring process there was a reduction in the number of universities and universities of technology from 36 to 23 at the time of this study (Appendix A). The challenges stimulated by this restructuring process included de-racializing education; forging new institutional identities and cultures through the progress of new institutional missions; social educational roles; and academic programme mixes. During this transition the vigour had been fixed at policy level, and more recently on the impact thereof. While the higher education sector in South Africa is predominantly public, the private higher education sector has been increasing swiftly, with many created in partnership with public institutions (Human Sciences Research Council of South Africa 2006: 2).

Higher education is an environment engaged with intangible objects and has been faced with enquiries about IP. Intellectual property has become vital to higher education because of economic, political and social forces, thus making knowledge and research important possessions in the information age. An age-old system of IPR's exists in South Africa dating back to 1916, when the all-inclusive national legislation (Patents, Designs, Trade Marks and Copyright Act No. 9 of 1916) was passed, much earlier than most industrializing countries (Kaplan 2009: 1).

Many factors and forces contributed to the formation of the present South African national innovation policy, in which universities played a large role in the development and implementation thereof. Participation by universities in commercial activities was envisaged to be an important component of the national innovation policy movement. Patent protection appeared to be the ideal solution to protect academic innovation from outside intrusion and infringement. As technology changes the role of patents becomes superior, with policies and practices evolving in the academic environment.

5.2 Challenges in higher education

The global effect of challenges faced by societies demands the need for innovation in all domains. The prevalent recognition that tertiary education is a major driver of economic competitiveness in an increasingly knowledge-driven global economy has made high-quality tertiary education more important than ever in both industrialized and developing countries (Pillay 2011: 17). As the rapid need for innovation increases, the expectation is therefore that the contribution by higher education will also increase.

In January 2012 the Minister of Higher Education and Training identified the key challenges facing South African higher education and set out a route for overcoming the obstacles. Habib (2012b: 5) argued that higher education in South Africa is confronted with major priorities which include the need to produce a skilled human resource base which is desired for growth; the need to produce a new generation of academics to endure the higher education system; and to produce high excellence research and innovation to enhance global competitiveness.

The core focus was on employment and economic enrichment, and how the higher education system could best contribute to this national imperative. It also placed a strong emphasis on transformation and redress within the higher education system. This encouraged the aim for increased growth in research output in the form of postgraduate qualifications, patents and products arising from research output (South Africa 2012a: 39). There has been a general effort to drive South Africa's transformation towards a knowledge-based economy, in which the creation and diffusion of knowledge leads to economic benefit and enriches all fields of human endeavor (South Africa 2012b: 12). The call in support of the IPR Act therefore suggests the impetus towards national needs, with the appropriate open licensing and overarching policy framework on IPR's in higher education (South Africa 2012a: 60).

As Bailey (2011: 1) submitted, the IPR Act heralds a new mode for the higher education sector to do business. Bailey (2011: 1) further added that the basic idea of the Act is to make certain that taxpayers' investment in research at HEI's, through Government-funded projects, is protected by patents and other forms of IP protection; that it is commercialized; and that South African's benefit from these projects by way of job creation, business creation and access to new products.

The IPR Act has also been critiqued from various perspectives, as it is believed that it may present adverse effects on the commercialization of university innovation (Barratt 2010: 2; Chetty 2010: 1; Gray 2010: 2). Some of the perspectives are presented below:

- It can be counter-productive to achieving the objectives of promoting commercialization. There have been reports that IPR increased individualism and counter-accusations which are not unique to South Africa. International trends have demonstrated that in environments where the rate of innovation is high, counter-accusations of IP theft are common (Simelane 2013: 42). Researchers within universities are expected to seek permission and declare outputs to their IP&TTO before publishing or conference presentation. This leads to a time lag between the evaluation and issuing of permission and publication in accredited journals. Subsequently, the scientific vigor of research and its contribution to knowledge dissemination has declined (Simelane 2013: 44).

- The Act has a broad approach to the conceptualization of commercialization; for example, it includes knowledge that should be socialized rather than commercialized.

- The approach to IP protection may present potential obstacles to scholarly publication.

- It contains provisions that may be unnecessarily onerous for universities and academics.

The South African IPR Act states that inventions should not merely be registered for patent protection, but efforts toward commercialization attempts should be evident. Research undertaken at HEI's must be relevant to the needs of industry. This is a challenge that often occurs, as commercialization is largely dependent on industry requirements. Regulatory frameworks are also a potential challenge that may impact on HEI's in commercializing innovations. The challenge is maintaining a competitive position in domestic and international markets across a broad range of disciplines and segments, which is a position that HEI's are hoping to reach.

Mulder (2008 cited by Oluput (2009: 110) argued that IP&TTOs in South Africa are confronted with mutual challenges and they include: getting the institutional leaders to embrace technology transfer and commercialization activity and not simply paying lip service; loss of IP due to lack of awareness by researchers; absence of funds for patents; absence of funds for product development and commercialisation; difficulty in market penetration, both local and international markets and inadequate human resources. These obstacles according to Mulder, can be resolved by: use of cognizance raising to solicit invention disclosures; audit units to determine commercially viable inventions, give due attention to all invention disclosures; evaluation based not only on commercial potential but also social benefit; patent where applicable, full due diligence required before committing significant resources to patenting; licensing out for further development and spin-outs companies where appropriate.

5.3 Research and innovation

Innovation is firstly the development of a new idea, and secondly, of putting that new idea into practice. The innovation process is about taking new valuable products, eg. goods and services, to market. The ultimate stage of the innovation process is the commercialization phase, which is crucial for the success of an innovation. It is therefore understood that through innovation, an innovator attempts to present and deliver to the public a new and unique value. Commercialization is not conducted in isolation, nor in a vacuum. Within each country commercialization is part of a national system of innovation and is conducted within a set of national parameters, or what Gans and Stern (2003: 13) refer to as ‘common infrastructure’. Globally, governments pursue reforms to build world-class systems of higher education, which assure quality in both research and teaching. According to Kearney (2009: 11), by contrast the term ‘World-Class University’ tends to denote research-oriented institutions, although this should also recognize those which achieve excellence through innovative approaches to learning. The literature reveals that all economies expand from innovations that arise from a number of bases of which universities are only one, albeit a vital one.

Higher education institutions are facing challenges with the research function and its environment, which includes equity; quality; relevance; ownership; collaboration and networking. Managing a knowledge-based society can be an extremely complex process which involves mechanisms and strategic decision-making that should operate effectively for successful results. Kearney (2009: 13) reported that the elements range from traditional upstream aspects such as governance, policies and investment, to downstream management of knowledge institutions and workers, with due respect for interaction and adaptation and for specific cultural and ethical values.

As outlined by Sibanda (2009 cited in Taplin and Nowak 2010: 48), South Africa has been viewed as a resource-based economy with little appreciation for IP as an instrument of wealth creation. The Department of Science and Technology (DST) has designed a ten-year rolling plan which is hoped will transform South Africa into a knowledge-based economy.

There are various stages of an innovation life cycle that are difficult to separate. According to Collier (2008: 31) these firstly include the impact and prominence of innovation in an economy; secondly, public support for research at public universities; and thirdly, the implications of commercializing university research. Collier (2008: 31) additionally stated that the significance of university commercialization as a driver of the national economy is often assumed, however there exists few firm data sets and there is significant scepticism as to the precision of the assumption. Not all innovations are commercialized, therefore it must be understood that not all innovation results in success. This is supported by Brandt (2002: 6), who stated that "most die a lonely death, never seeing the light of commercial success", and reinforced by West (2013: 39), who stated that “99% fail - even an inventor, whose product is unusual enough to be granted patent rights, faces daunting odds. It is estimated that one out of every 100 patented products makes it to the market place and makes money”. The importance of innovation is acknowledged; without innovation one will be excluded in this competitive world by one’s competitors. Research and innovation have therefore increased in importance. Certain enabling environments encourage innovation, while research identifies how knowledge translates into innovative action which drives positive change.

Taplin and Nowak (2010: 49) outlined a case in South Africa where an innovator had developed a solar panel technology. The technology was developed in South Africa, however it was licensed for commercialization in Germany as part of Germany’s alternative energy policy. It was reported that the benefit of commercialization has been immense, as 300 000 jobs were created in Germany. These are the challenges that HEI’s face in South Africa; it is hoped the IPR Act 15 of 2008 will ensure that this type of action is not repeated in South Africa, as it would be to the detriment of the country.

The South African Government views the IPRPFRD Act as the anchor behind the DST’s ten-year plan in transforming innovation to solve the socio-economic challenges and accelerating economic growth. The Minister of Education has stated that South Africa has made progress regarding IP, and that it is clear that economic growth is gaining momentum and has made some breakthroughs compared with other African countries (Taplin and Nowak 2010: 51).

5.3.1 Structure of the innovation landscape

Higher educational reform and the reorganization of the higher education landscape have ensued and continue to ensue in countries globally. The CHE (2014: 30) indicated that the impetus for reorganization arose from changes in national and world-wide conditions.

Conditions that have an impact on the economy, the labour market and society have implications for knowledge, competencies and the skills base of graduates, as well as on the creation and application of knowledge. As an important source of new information, higher education must respond to the challenges of social, economic and cultural progress. Higher education must also be dedicated to achieving major enhancements in the quality of higher education, research, community service and innovation.

The role of each country in the creation of an innovative society is important for the well-being of citizens in the information age. South Africa was not unique in reconfiguring and reconstructing its higher education landscape. The problems and weaknesses of systems indicated changes that need to be achieved through the reconfiguration of the higher education institutional landscape. A more balanced landscape for higher education will provide a more focused framework for innovation. Figure 5.1 represents the South African innovation structure and institutional landscape within public management and HEI's.

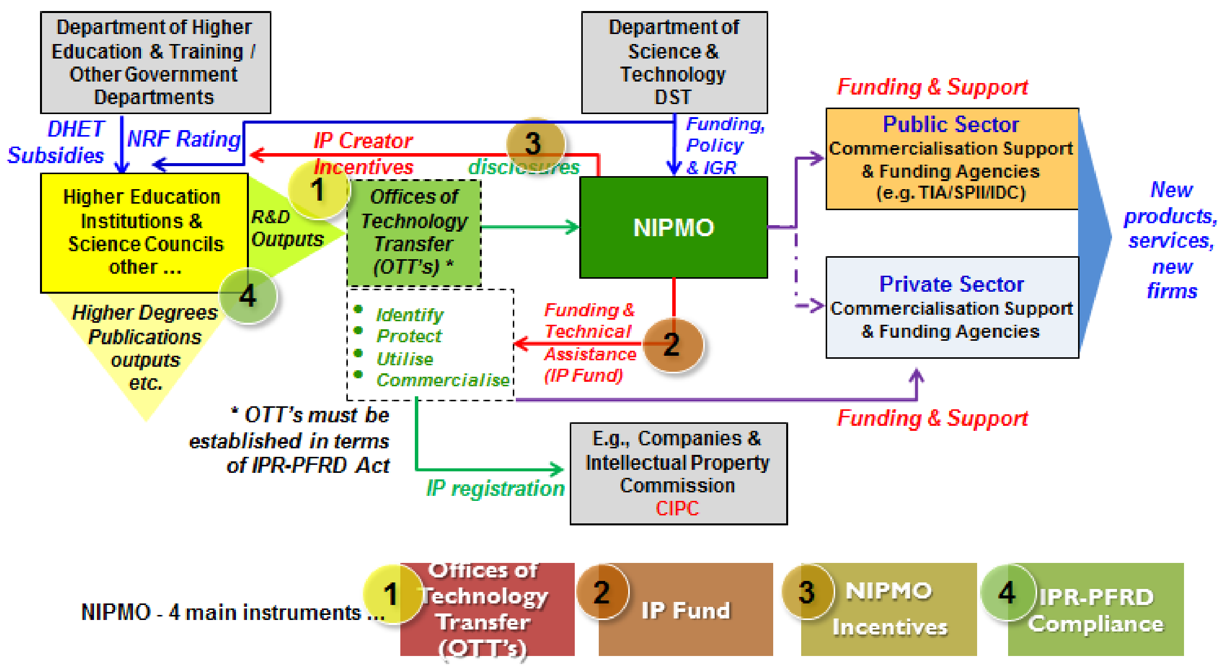

Figure 5.1 Structure of South African innovation landscape (adapted from Bertoldi 2014).

The traditional model of public administration was under scrutiny. The inability to address the diverse needs of modern economic and social systems was subject to inactivity and inefficiency. The public administration sector was therefore in need of reform, restructuring and change. The consequences included the incorporation of elements of NPM thinking, which was a product of restructuring and strategic change. As an example, the Companies and Intellectual Property Rights Office (CIPRO) was re-designed and renamed to become the Companies and Intellectual Property Commission (CIPC) of South Africa. Established on 1 March 2002, the new entity brought together two former directorates of the Department of Trade and Industry (DTI), the South African Companies Registration Office (SACRO) and the South African Patents and Trade Marks Office (SAPTO). This was in line with the move away from ‘bureaucracy’ and it was set-up as an autonomous agency. As explained in the Annual Report, the intent “was to establish a self-sustaining business agency, which would increase efficiency in the registration of companies, close corporations, cooperatives and intellectual property rights” (Companies and Intellectual Property Rights Office 2006).

As depicted above in Figure 5.1, the CIPC is the custodian of IP legislation in South Africa and reports to the DTI. The IP policy developed by the DTI defines the future of the innovation landscape in South Africa. The country has taken the direction of transforming its economy from being resource-dependent to a knowledge-based economy. Through the IPR Act No. 51 of 2008, South Africa has transformed the innovation landscape by providing guidelines for the use and management of IP which emanate from government-funded research. All universities report to the National Intellectual Property Management Office (NIPMO), which is an entity of, and regulated by, the Department of Science and Technology (DST). All Government departments have mandates and are funded according to those mandates. For example, the DST's mandate is Science, Engineering and Technology advancement and it has to implement policies and legislation that support that mandate. All Government Departments report through the Department of Performance, Monitoring and Evaluation, which in turn reports to the different Portfolio Committees within Parliament as illustrated in Figure 5.1.

Strategies to support technology transfer are a central component of the wider innovation system. The interlinking of institutions and industry forms partnerships that create an enabling environment not just for the origin of new technologies, but for their application, dissemination and the commercialization thereof. As shown in Figure 5.1 HEI's are supported by NIPMO, which provides funding and technical assistance. This support is further complimented by funding agencies, namely the TIA, SPII and IDC, which provide commercialization support. These structures were implemented in an effort to assist institutions by providing financing and technical support, which was found to be lacking in the HEI sector.

Higher Education South Africa (HESA) is a membership organization representing South African universities. This organization supports the rationale for the IPR Act as an endeavour in the direction of strengthening the National System of Innovation (NSI). In this way broader society may benefit from the vital role played by higher education, while making South Africa globally competitive as well as contributing to national priorities and prerequisites.

Higher education systems strive to achieve equity and excellence that are essential to attaining improvements in the quality of higher education, community service, research and innovation. Reform and innovation are continuous processes which provide for improvements. A goal of higher education is the contribution made in the dissemination of new knowledge and the evaluation of new applications of knowledge (Council on Higher Education 2014: 46). This can be achieved through high-level intellectual analysis and research. The higher education system in South Africa has the strengths and the potential to contribute to the economic and social expansion needs of South Africa.

Research universities are therefore identified as important sources of fundamental knowledge and innovation. High-level study necessitates suitably competent staff. The ability of universities to continually conduct high-level research is typically measured by appropriately qualified staff, which is essential in conducting and supervising high-level research (Council on Higher Education 2014: 48).

5.4 Focus on innovation effort

A well-managed and properly functioning national system of innovation contributes positively for all South Africans to enjoy the economic, socio-political and intellectual benefits of science and technology. The generation of innovative ideas, products, institutional arrangements and processes all contribute to the country's ability to address the needs of its citizens. This is essential within the perspective of the demands of global commercial competitiveness, justifiable growth and equity reflections on the legacy of the past.

The development and application of science and technology within the national system of innovation (NSI) in South Africa has been central to the success of the country's Growth and Development Strategy (GDS), in order to address the essential needs of all South Africans. In keeping with the diversity of political, social and economic changes introduced by the Government, the NSI is intended to support the six pillars of the Growth and Development Strategy with a framework for science and technology. This is intended to unite all South Africans around a common programme to fight poverty and inequality and to foster a spirit of unity; to foster an active citizenry and an inclusive economy; and to inculcate the responsibilities of leadership throughout society by working together to solve problems, as evidence in the White Paper on Science and Technology (Department of Arts, Culture, Science and Technology 1996: 8). This was supported by Manuel (2012:

1), who stated that “science and technology will continue to shape development in ways that will open up opportunities for humanity in general, including poor countries.” Manuel (2012: 1) further highlighted that innovation is essential for a middle-income country such as South Africa to progress to a high-income status. The incentive of the NSI is therefore essential in the drive to enable all South African’s to attain social, political, economic and environmental aims.

The management of innovation is of tactical significance to universities, since it can derive substantial benefits from an effectively maintained portfolio. A survey conducted by the Association of University Technology Managers (AUTM) (2012: 6) reported on the fiscal year 2009-2010. The results of the survey indicated that universities in the UK generated a total of £84m in revenues from patenting activities. This was understood as part of the economic impact of knowledge in creating jobs and delivering innovation into the economy. During the same period over 5,600 USA patents were issued generating over US$2.267 billion in licensing revenue, thereby creating 550 new companies that were formed to commercialize innovations arising from publicly funded research. It is hoped that the South African IPR Act can achieve similar success from the commercialization of university innovations.

To foster innovation there is a need to bring knowledge and know-how closer to each other (Kamoun 2008: 1). This is complemented by Wolson (2007: 346), who stated that there is a need to influence research at universities in order to ensure the commercialization of quality innovations that are usable, relevant and with market potential. This is illustrated in Figure 5.2 as the strategic focus of innovation effort. Bansi (2012: 121) concurred that the priority for SA universities is to identify research with industry needs, market potential, and to transfer innovation to the marketplace. Technology roadmaps, referred to as technological forecasts, are therefore indicators of new technology requirements as anticipated by industry. Grobler (2013: 1) suggested that university researchers ought to be guided by industry requirements when aligning research efforts combined with innovation strategy. University research undertaken in collaboration with industry requirements has a greater potential of success in commercial application. South Africa's national innovation effort is an investment in the future. Secondly, technology must be integrated within social activities, education, delivery of services and economic activity. The necessary resources must be devoted to scientific and technological R&D. Ensuring a balanced economy, identification and development will further expand the base to compete successfully within the dynamic world economy. The IPR Act supports the strategy which is in keeping with the illustration in Figure 5.2 below.

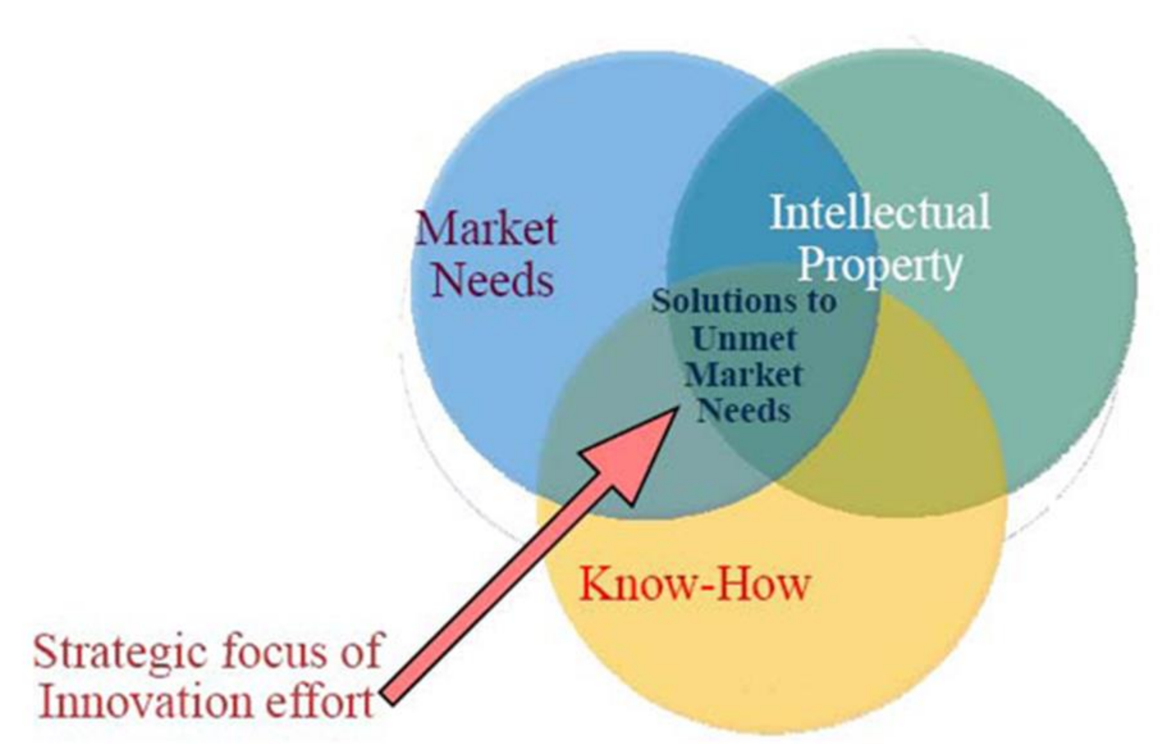

Figure 5.2 Strategic focus of innovation effort (**adapted from Wolson 2007).**

The explosion of intellectual property licensure for commercialization is widely attributed to the Intellectual Property Rights Act No. 51 of 2008. With assistance from the IP&TTO's at universities, there are numerous rewards for the commercial licensure of innovation and discoveries. Awareness and the role of the university IP&TTO is beneficial to innovators for optimal utilization of resources and capacity with its objectives.

The South African protection of intellectual property rights is according to international standards, and is even considered to be advanced. This is supported by Teljeur (2009: 50), who argued that South Africa is seen as 'advanced' by international standards in terms of SA legislation. Lesser (2011: 2) gave support to this stance by ranking the South African IPR's regime as the highest developing country. This was based on indicators that include TRIPS compliance, PCT applications, and prices as proxies for efficiency of the patent regime. South Africa is a member of the Paris Convention, the Patent Co-operation Treaty (PCT) and the Agreement on the Trade Related Aspects of Intellectual Property Rights (TRIPS). As posited by Teljeur (2009: 50), however, this reputation is undermined by the absence of a patent examination capacity and enforcement concerns. The South African patent office functions as a non-examining office. Wolson (2007: 346) concurred with Teljeur (2009: 50) in explaining that the consequence of a non-examining patent office means that registration of a patent does not necessarily result in the patent being valid, which weakens the importance of obtaining a patent in South Africa.

5.5 Agencies and service delivery units in support of intellectual property

As part of developing institutional structures to facilitate technology development and its progression into national and international markets, the Technology Innovation Agency (TIA) and the National Intellectual Property Management Office (NIPMO) were established.

5.5.1 Technology Innovation Agency

The TIA was established in terms of the Technology Innovation Agency Act, 2008 (Act No. 26 of 2008), with the objective of motivating and escalating innovation to improve economic enrichment and the quality of life for all South Africans by evolving and exploiting technological innovations. The TIA established regional offices in various provinces with a mandate to facilitate widespread access and support for technopreneurs across the country, thereby enabling them to commercialize more of their technology products and services. The TIA further established a network of centres of proficiency focused on market opportunities, in order to build a competitive edge for South Africa (Department of Science and Technology 2010: 7).

The broad objectives of the TIA (Department of Science and Technology 2007: 7) are to:

- Act as a technological agency to provide funding and complimentary services to bridge the gap between the formal knowledge base and the real economy.
- Stimulate the development of technology-based services and products.
- Support the development of technology-based enterprises, both public and private.
- Provide an intellectual property support platform
- Stimulate investment (venture capital, foreign direct investment, etc.)
- Facilitate the development of human capital for innovation.

This plan included the requirement to establish an Intellectual Property Management Office to improve the protection of IPR's and to confirm synergy with other policies. It also advanced the national capacity to achieve technology licensing and commercialization (Department of Science and Technology 2007: 26).

The Technology Agency annual report 2013/2014 (Technology Innovation Agency 2013/2014: 2) indicated that the agency continued to support the development of new technologies with an increased interest in risk funding and technical support. During 2013/2014 a total of 103 applications were assessed, worth R1.5 billion. Approximately R376 million was disbursed on innovation skills and project-related funding. The TIA has established a seed funding programme with the aim of assisting universities in translating university research outputs into fundable ideas for commercialization. The TIA's 2014/15 focus is to improve the organization's pre-investment customer processes and to enhance post-investment management support activities (Technology Innovation Agency 2013/2014: 2).

5.5.2 National Intellectual Property Management Office (NIPMO)

The NIPMO was established as a specialized service delivery unit within the Department of Science and Technology. In terms of section 8 of the Act, the NIPMO is liable for the control and execution of the IPR Act. This office has a supporting role through facilitating, co-ordinating and capacity building; developing guidelines; and the management of an Intellectual Property Fund. Concomitantly, it has a monitoring and compliance role through the receipt of reports on IP commercialization status; approval of offshore transactions; overseeing the Government's walk-in and other rights; and approving the full-cost models (South Africa 2008: 4).

As regulated by legislation the responsibilities of NIPMO include the following (South Africa 2008: 5):

- Promoting the objectives of the Act and statutory protection, management and commercialization of IP referred to as a recipient of public funding for R&D.

- Ensuring the ability to consider and deal with any IP referred to it by a recipient in terms of the Act.

- Liaising with the recipients or any other party it deems fit to determine the viability.

The NIPMO functions (South Africa 2008: 6) include:

  - Managing information in respect of IP contemplated in the Act, including data concerning the recipients.

  - Providing incentives to recipients and their IP creators, to reward them for proactively securing protection for IP and the commercialization thereof, and in general for the promotion of innovation.

  - Providing assistance to institutions, e.g. the establishment of offices of technology transfer and related capacity-building.

A series of training workshops was held for recipients of public funding during 2009-2012. The function of NIPMO is not just a monitoring (compliance monitoring, review and enforcement) function, but also a managerial and supportive function in respect of the Act on behalf of the Government. In this regard, the NIPMO is the interface between the public and private sectors on issues pertaining to R&D, as well as IP management and commercialization. The key tasks of the NIPMO relating to stakeholders were IP cognisance and entrepreneurial participation. A challenge relating to itself was independence from the DST in respect of oversight and compliance functions.

Challenges experienced by NIPMO since inception were in specific areas, such as:

- Resources: financial and human constraints internally within the NIPMO structure.
- Stakeholders: IP awareness with regards to process and procedures. A series of workshops were therefore held to assist with awareness and compliance.
- Support from senior management (senate, executive, etc.) in Government and in the HEI's and science councils for the third stream mandate.
- The availability of entrepreneurs to take the technology to the market: a shortage of experience and skill in the field of technology transfer.
- De-risk funding and legal/administrative support during new company set-up.

The aim of the NIPMO is to ensure that recipients of public funds evaluate, record and account for the benefits to society from research results. Recipients must defend IP emanating from publicly financed research from misappropriation and confirm that it is available to the people of South Africa. Further, the recipient is obliged to identify commercial prospects. The fact that academics were engaging more in research for publication purposes than for patent purposes needed to change. The Department wanted to find a balance between the two. The next section discusses intellectual property management as controlled by legislation in South Africa.

5.6 Intellectual property legislation in South Africa

One of the challenges identified by the National Research and Development Strategy of 2002 was scarce IP legislation and infrastructure. In particular, it was established that innovations from publicly financed research were not well protected and managed. Within this context, the Intellectual Property Rights from Publicly Financed Research and Development Act, 2008 (IPR-PFRD Act 51 of 2008), came into effect.

The Intellectual Property Rights from Publicly Financed Research and Development Act, Act No. 51 of 2008, commonly referred to as the IPR Act, was signed by the President of South Africa on 22 December 2008 with a proclamation date of 2 August 2010. The primary aim is to ensure that IP stemming from publicly financed R&D is protected and commercialized for the benefit of the people of South Africa, with social, economic, military or other benefit.

Funds were provided for the formation of technology transfer offices at institutions, and to provide for matters connected therewith, in order "to make provision that intellectual property emanating from publicly financed research and development is identified, protected, utilised and commercialized for the benefit of the people of the Republic, whether it be for a social, economic, military or any other benefit" (South Africa 2008: 7).

5.6.1 Rationale for the IPR legislation

The IPR Act 51 of 2008 was advocated by the DST, which implied a positive step towards improving the management of IP stemming from publicly funded research. According to Sibanda (2008: 17) the Act formed its base from the 2002 National Research and Development Strategy, which recognized a need for a legislative framework for the management of IP emanating from publicly funded research. The DST indicated that the IPR Act is aptly positioned to emphasize the potential of IP in contributing to economic growth, wealth creation and social upliftment through research work that was funded by the government. The IPR Act stressed the importance of ensuring accountability regarding government funded research expenditure. During the formulation of the IPR

Act it was argued that the Act was to inspire publicly funded research institutions to be innovative and industrious in the knowledge economy (Department of Science and Technology 2007: 5). A discussion on the rationale for the IPR Act is highlighted.

- The absence of a national IP defense and commercialization agenda was found to prejudice South Africa as public funded research was reported to being underutilized (NACI 2003: 3). Further, IP was being "lost to foreign jurisdictions" or "sitting on shelves" and inadequate in contribution to national socio-economic growth (Sibanda 2009: 6). South Africa's frail patent profile was quoted as an indicator of "a major weakness in South Africa's ability to become a full player in the global knowledge economy", with "increased patenting activity" and "building capacity in entrepreneurship and technology transfer within publicly funded institutions" being recognized as corrective solutions (Department of Science and Technology 2007: 15). The regulation provides for the protection and commercialization of IP from public funded research, which placed restrictions on off-shore IP relations to limit the forfeiture of IP to foreign jurisdictions. Circumstances that apply to off-shore businesses are stipulated in Section 12 of the Act, which requires institutions to notify the NIPMO and to obtain approval prior to concluding any off-shore exclusive IP transactions (exclusive licenses or assignment), i.e. licenses and assignments granted outside South Africa (Intellectual Property Rights Act 51 of 2008). Such approval is granted pursuant to a number of concerns, comprising the requirement that NIPMO is content that there is inadequate ability within South Africa to commercialize the IP in question.

- The legislation encourages universities to register patents, thereby accumulating large portfolios, but has neglected the possibilities of weak commercial potential. This is supported by Webster and Jensen (2011: 447), who argued that the legislation's stress is on patent commercialization as a revenue of economic growth, but it fails to recognize that patents do not always result in commercialization and economic progress. It has therefore been found that some institutions have large collections of weak patents barely meeting the legal patentability requirements. This situation was reinforced by Wolson (2007: 356), who argued that in the absence in South Africa of an examining patent application system is the main cause of large patent portfolios not having commercial value. The DST acknowledges that "patenting for the sake of patenting is not adequate", but argues that an emphasis on patenting is a prerequisite for successful commercialization in alliance with South Africa's technological growth strategy (Sibanda 2008: 31).

- The IPR regulation can lead to improved progress in research output in the form of postgraduate qualifications, patents and concepts arising out of research (South Africa 2012a: 39). This aim is to "help drive South Africa's transformation towards a knowledge-based economy, in which the production and dissemination of knowledge leads to economic benefits and enriches all fields of human endeavor" (South Africa 2012b: 12). The IPR Act therefore suggests an embracing and revision in agreement with national requirements, with a suitable open licensing policy agenda for use by all higher education stakeholders (South Africa 2012a: 60).

- The IPR Act aims to address the situation whereby IP generated by researchers remains unutilized at universities or is sold off to private investors, often overseas, without value ensuing to the university or to South African citizens. Moore (2009: 2) stated that the over-arching opinion is that where public funding has been utilized to produce IP, the Government and the South African public should obtain some value from that IP. Under the IPR Act 51 of 2008, each institution (which includes universities and science councils) has access to a Technology Transfer

Office which determines whether IP generated from public finance is protectable and worth commercializing.

- For researchers, the Act impacts particularly on the sharing of information and research results. The Act requires institutions in receipt of public funds to identify and protect potential IP before public disclosure. The onus is on the researcher to disclose potential IP to the institution in order to be protected before it is presented publicly as a journal article, thesis, or any other publicly available medium. The ownership of such IP is automatically assigned to the institution. An imposed time limit is 90 days, within which potential IP must be disclosed to the institution. An evaluation of the IP is considered, and thereafter an application for protection is filed. Thus, the Act encourages a new mind set amongst researchers to consider the social and commercial potential of their research. The receiving institution of R&D funds must evaluate, record and account for the potential value to the appropriate government entity, namely the NIPMO which is the specialised service delivery unit (SSDU) that regulates publicly financed research.

- The IPR Act is an intervention by government to increase innovation in South Africa, and to identify concerns around publicly funded research. The concern from an IP administration perspective was an absence of harmonization in managing IP generated from publicly funded research. Prior to 2008 the Higher Education Act did not accommodate innovative creation. Ownership, commercialization and technology transfer of IP was not given much consideration. The lack of benefit- sharing policies to reward creation afforded no incentive to researchers at higher education institutions to continue to be innovative. This often resulted in IP leakage to overseas countries, which resulted in minimal or no benefit to the citizens of South Africa. The public was demanding more accountability on the use of Government funds (Quest 2008: 57).

- Recognizing that HEI's are beneficiaries of public funds, the ownership of the intellectual property produced from such research resides with the HEI. The IPR Act awards recipients of public funds the right of IP ownership on the understanding that in the instant that a recipient decides not to retain the right, the Government may acquire such IP should it be in the national interest. Incentives for IP creators are guided by the benefit-sharing arrangement as per the IP Act. The Act allows institutions and IP creators to negotiate on mutual benefit-sharing arrangements. Higher Education Institutions and innovators have an obligation to ensure that the IP created is commercialized to the benefit of the citizens of the country. This is to prevent the forfeiture of IP to off-shore controls with little or no advantage to South Africa. The IPR Act also regulates that situations are met prior to the exclusive assignment of an IP to an off-shore authority being concluded.

The Government can also exercise a right to IP generated from public finance. In the event where IP may be required for the benefit or emergency need of the country, the Government may claim such IP, in the process ensuring that the recipient is not prejudiced. The NIPMO ensures effective implementation through capability expansion, advisory services, the financing of IP costs, public rights and regulatory functions in terms of the IPR Act. Although intellectual property activities such as patenting at universities did occur prior to the IPR Act it was far from systematic, which posed challenges to the innovator and the institution alike.

5.7 Patents and commercialization

It is widely believed that policy instruments such as patents are necessary to reinforce excludability and thus stimulate *ex ante* investment. Accordingly, obtaining a patent affords the owner greater confidence in the ability to appropriate profits and will therefore ultimately lead to increased commercialization. Little attention is focused, however, on the importance of patents in the actual commercialization process.

In South Africa patents are regarded as a technological indicator examined by the Department of Science and Technology (Pouris 2005: 222). This is further supported by Ryu (2012: 1), who stated that patents provide a yardstick for the Government to evaluate the process of converting innovation into economic assets. While there are several good innovation performance indicators, Oluput (2009: 1) concurred that the patent system serves as an excellent yardstick for the measure of the innovation potential in South Africa. Also, the total number of patents has been utilized as a measurement of university commercialization effort by organizations such as the AUTM and Government agencies. According to Collier (2008: 58) patent portfolios are a popular metric measure amongst economists, largely because they are readily available, describe a tangible output, and results arising from their analyses are reproducible. These form a narrow metric though, with arguably limited potential to describe the commercial results being achieved by universities (Renault *et al*. 2008: 5). The review by Duguet and MacGarvie (2005 cited in Hall and Rosenberg 2010: 837) found that "… qualified support for the premise that patent citations are associated with flows of new technology. However, the validity of using citations to measure knowledge flows varies with the source or destination of the knowledge transmitted and the channel through which it is transmitted".

The commercialization of university patents has become an important imperative which leads to the manifestation of an entrepreneurial university. This importance can be seen through university contributions towards local economic development (Shane 2004: 11). Ismail, Majid and Omar (2011: 80) indicated that South African universities continue to register patents for their innovations, even though the ratio of exploited patents compared with unexploited patents remains relatively low. Patent registration is a method of protecting and rewarding effort by granting a legal monopoly to the inventors and patent owners. It is not the only method of protecting technology or ideas, although since it is a monopoly right it can be a strong deterrent for competitors (Baugher 2015: 1). It is often found that innovators make the common mistake of trying to trade their innovation without acquiring legal protection and prior to turning the concept into something more tangible. It is important to file a patent application and to yield a functioning prototype prior to attempting to commercialize an innovation. Literature reveals that only a small percentage of innovations with registered patents have successfully reached the commercialization stage of the innovation process. Fortunately, the relatively low success rate of innovation commercialization does not discourage innovators from innovating and attempting to commercialize their innovations. Innovators are generally optimistic and confident in the potential of their innovation generating revenue.

The key issue of effective commercialization depends on two prime features: relationships and people, and relationships rely on people. The characteristics involved in the management of innovation and commercialization is of crucial importance, together with buy-in from the management level of an institution. In a study conducted by Wua, Welch and Huang (2015: 1), the results revealed that commercialization is expressly determined by distinct factors such as the inventor's approach towards commercialization, additional research piloted during patent review, and alliance with industry scientists on the principal research. Essentially, success in commercialization depends on the value, skill, expertise and character of the people involved. Relationships with venture capitalists are also of the utmost importance.

Wua, Welch and Huang (2015: 1) also identified two types of innovation: one is opportunity-based, which is an innovation that is not predicted as patentable at the onset of projects. The second is an intention-based innovation that arises on research ventures that expect commercial results before the start of research. With this in mind, Webster and Jensen's (2011: 445) study on the commercialization outcomes of Australian innovation has revealed that patents impact positively, but play a modest role in the decision to manufacture innovation. It must be borne in mind that most innovation in research studies are potentially patentable, and the title of a patent increases the prospect that a manufacturing effort will be made, however the fact that undetected variances in the core worth of the innovation may partially explain a result. Webster and Jensen (2011: 445) revealed that often unpatented innovations are also commercialized. Thus, they concluded that patents are neither a necessity nor an adequate condition for commercialization. The aforementioned conclusion should therefore not impact on the commercialization of university innovation in South Africa, as the non-examining patent system should not negatively impact on the rate of commercial application.

The need to unleash scholarly action that converts basic research into commercially viable products has increased. This need often requires innovators with an entrepreneurial mindset, as compared with researchers conducting purely basic research. This type of engagement often does not account for results that usually count towards career advancement. According to Sanberg *et al.* (2014: 6543) there is a divide between commercialization activities and motivations for researchers in terms of merit elevations, tenure, and career advancement. Aside from the financial benefit from licensing, which is often generally low, there is almost no benefit to a faculty member's merit raises, tenure and career advancement. This sentiment is not prevalent in South Africa alone, as literature reveals that it is a global university practice.

Literature also reveals that the benefit of patents and commercialization has evolved, which extends beyond revenue generation. There are various advantages, such as opportunities for research funding which also includes access to further finance for institutional investment; satisfying high scholarship levels; amplified prestige; public benefit and economic enrichment. A change in academic culture from only recognizing basic research to the acknowledgement of use-oriented research, development and commercialization should inclusively be rewarded. The introduction of an incentive system of rewards would encourage researchers to engage in increased commercial activity. This is supported by Sanberg *et al* .(2014: 6547), who stated the importance of encouraging innovation in drawing attention to the diminished impact patents currently have on the process of tenure acquisition and career advancement at universities.

5.8 Role of the Department of Science and Technology (DST)

South Africa has historically been a resource-based economy and has some distance to cover in becoming a knowledge-based economy (Department of Science and Technology 2008: 3). According to the DST (2008: 2), "the knowledge-based economy rests on four interconnected, interdependent pillars, which include innovation; economic and institutional infrastructure; information infrastructure and education".

The DST is accountable for scientific research in South Africa and directs the supervision of the country's moderately well-built science system. Its mandate is derived from the 1996 White Paper on Science and Technology. The DST, in alliance with other Government departments, intends to boost innovation through a sequence of fixed interventions in tactical areas. The basic premise is that science, technology and innovation (STI) play a vital role in commercial growth and socio-economic expansion. Science and technology is South Africa's prospect for improved competitiveness and economic growth. Scientific and technological innovation has become crucial for the growth of competitive advantage in the global economy and in addressing strategically evolving needs.

The DST (2007: 25) reported that the 'innovation chasm' was found to be a major weakness in the economy, and that South Africa has yet to effectively mobilize innovation

In support of economic growth. This problem was initially identified by the National Research and Development Strategy, which stemmed from the realization that the domestic market for medium-high technology products and services and local research had nothing in common. This resulted in the extensive importation of technology and intellectual property, which culminated in an unfavourable technology balance of payments.

The grand challenges outlined in the DST’s (2007: 11) innovation towards a knowledge-based economy ten-year plan, addressed many areas which included social, economic, political, scientific and technological benefits. This was designed to stimulate multi-disciplinary thinking and to challenge the country’s researchers to respond to existing challenges, create new disciplines and develop new technologies.   The main areas of challenge included (Department of Science and Technology 2007: 11):

- The Farmer to Pharma value chain to strengthen the bio-economy.
- Space science and technology.
- Energy security.
- Global-change science with a focus on climate change.
- Human and social dynamics.

of which are illustrated in Figure 5.3 with a discussion that follows:

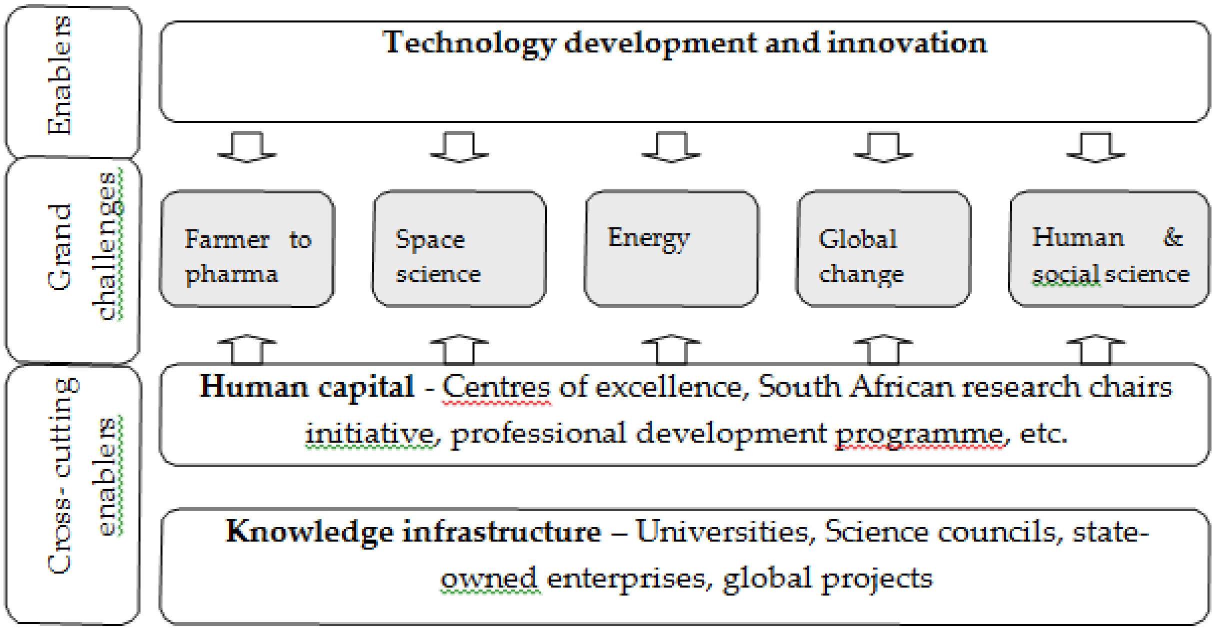

Figure 5.3 Grand challenges and enablers of the ten-year plan (adapted from the Department of Science and Technology 2007).

Each of the grand challenge area of focus includes the following (Department of Science and Technology 2007: 11):

- **Farmer to pharma** - As illustrated in Figure 5.3 above, life sciences and health are part of the value chain to strengthen the bio-economy. South Africa strives to become a world leader in biotechnology and pharmaceuticals, based on its indigenous resources and knowledge base. In order for the biotechnology industry to grow, a number of critical factors need to be satisfied, which include improving the funding mechanisms to close the gap between basic research and commercialization, and for the response time between application and receipt of funding to be enhanced. The country is well-positioned to derive strong socio-economic benefits with a supportive policy environment and from investment in platforms to bridge the gap between research and commercial application.

- **Space science and technology** – Space applications are essential in addressing challenges to become a key global contributor in expanding the limits of space science and technology. The South African Government has therefore proposed a National Space Agency to address three strategic objectives, which include: environment and resource management; safety and security; and innovation and economic growth. A core objective in this area is to win a growing slice of the global satellite industry (Department of Science and Technology 2007: 16).

- **Energy security** – South Africa's energy supply infrastructure must be accelerated to ensure sustainable growth. While immediate measures to resolve the existing tight supply are crucial, the long-term infrastructure requires prioritization with extreme urgency; this includes a more structured planning relationship between the Government and the private sector (Department of Science and Technology 2007: 18). The Government has announced its intention to place greater reliance on nuclear power, natural gas and various renewable forms of energy.

- **Global climate change** –South Africa is well-positioned as a laboratory to make a major contribution to understanding climate change. Worldwide, gases and other emissions are responsible for altering the earth's climate. Although most of these gases are produced by a few countries, the effect is global. Urgent responses and research on prevention are both required. South Africa has the potential to lead research in terms of understanding and projecting changes to the physical system. The impact of these changes and mitigation will limit long-term effects (Department of Science and Technology 2007: 22).

- **Human and social dynamics** – According to the DST (2007: 23), human and social dynamics are at the core of nearly every major challenge facing South Africa, from climate change to creating a competitive and innovative workforce. As

South Africa strives to become an innovative society, it is essential to support public understanding and engagement with science. The fifth grand challenge is to increase the anticipation in change by understanding the dynamics of human and social behaviour. This extends to better understanding cognitive and social structures that create and define change, in order to assist people and organizations to better manage rapid change (Department of Science and Technology 2007: 22). The government's strategy is that the public are not just passive recipients of science and technology, but are considered as the most important players in the process that shapes the focus and patterns of science, technology and development.

The issue of addressing the 'grand challenges' presents its own set of challenges, due to the open-ended and transformational nature of the matter. Grand challenges can be seen as priorities for R&D and innovation stimulation. The open-ended socio-economic missions induces system transformation. The new challenge pertains to elements and forces which have to be mobilized, guided and integrated, which also includes social innovation.

The DST's grand challenge draws attention to the social and human dynamics of development as one of the main focus areas, however a plan of action to implement the process was not clear. The National Development Plan also identifies major challenges, although the lack of a significant plan to achieve an active cohesive citizenry that buys into constitutional values was absent. It was envisioned that progress in the above-mentioned areas would be based on the three foundations: technology development and innovation; human capital; and knowledge infrastructure. Figure 5.3 is an illustration of the interconnections between these foundations and the grand challenge programmes. The government had to address the 'innovation chasm' to enable the above challenging goals to be realized. According to the DST (2008: 5) this meant improving access to finance, creating an innovation-friendly regulatory environment and strengthening the national system of innovation towards knowledge generation and collaboration with international partners. The DST further indicated that the major obstacle to the commercialization of technological innovations is financing, which is due to the high risk and complexities of R&D investments (Department of Science and Technology 2007: 25). Emerging public/private partnerships with the potential to help in closing the financing gap and to become effective financing vehicles for medium-high tech innovations, are some of the possible solutions.

It was established that 90% of the DST's annual budget of R4.5bn for 2010/11 was directed towards public institutions for R&D. The challenge experienced was that the socio-economic returns to South Africa from this R&D were limited. A relatively small number of only 5% of South Africa's patents in the USA and Europe were from public research institutions, and IP was lost to foreign institutions.

The DST being the custodial co-ordinator for the development of the National System of Innovation (NSI) influences this system through key strategies such as the National Research and Development Strategy (NRDS) and the Ten-Year Innovation Plan (TYIP). Implementation of the plan will follow an all-inclusive approach. It will be implemented by various National System of Innovation stakeholders, mostly led by entities such as Research Councils and the Technology Innovation Agency that reports to the DST. These strategies are briefly discussed in the following sub-sections.

5.8.1 National System of innovation (NSI)

The National System of Innovation (NSI) in South Africa consists of institutions and organizations that play various complementary roles in the production of scientific knowledge and technological innovations in the country.

The DST and the South African Cabinet arranged the foundations for the NSI with a sequence of strategic documents that emphasized the necessity to strengthen the place of R&D in the economy. These direction-setting ingenuities proved as quantifiable growth throughout the NSI and the economy. The DST felt that for South Africa to rise to the global challenges the NSI had to focus on long-term objectives. The Government enquired about the NSI's failure to commercialize the results of scientific research (Department of Science and Technology 2008: 2). In this regard, the National Research and Development Strategy (NRDS) and the 2007 Ten-Year Innovation Plan (TYIP) reflects their importance in attempts to commercialize research output. The character of the NSI reflects how knowledge policies, institutions and organizations as a collective entity negotiate challenges in order to realize shared goals (Manzini 2012: 6).

5.8.2 National Research and Development Strategy (NRDS)

The White Paper on Science and Technology (Department of Arts, Culture, Science AND Technology 1996) created the policy framework for the then Department of Arts, Culture, Science and Technology (DACST) to establish policies and strategies for the strategic development of science and technology in South Africa. During 2002 the South African Cabinet approved the NRDS as the basis for the NSI (Department of Science and Technology 2002: 2). An integrated approach was emphasized by the NRDS, which included human resource development; knowledge generation; investment in science and technology; infrastructure; and improving the strategic management of the public science and technology system.

The NRDS required performance and response in key areas which included: enhanced innovation; providing science, engineering and technology (SET) human resources and transformation; and creating an effective government S&T system. It is in this context that the DST had been established as a separate department to ensure greater co-ordination and integration, as well as better management of all Government funded science and technology institutions, and to provide a holistic overview of public expenditure on science and technology (Department of Science and Technology 2007: 3).

The NRDS was designed to impact on the quality of life and wealth creation using science and technology. Some of the ways in which the impact was directed included that the quality of life was to be measured by technology achievement and percentage growth in gross domestic product from the implementation of science and technology; human capital essential for technology progress; and business performance by industries importing knowledge that the country lacks. The NRDS complemented the vision of the White Paper by specifying details of the institutional change of public innovative capabilities (Department of Science and Technology 2002: 76). This consisted of three key priorities: firstly, a cluster of innovation programmes were established which included biotechnology, information technology, manufacturing technology and technology for poverty reduction. The second priority was to strengthen and refocus state-funded science, engineering and technology research. Lastly, the NRDS proposed the creation of an R&D policy by creating a clear distinction between the roles of sector departments such as Agriculture and Health, and the Department of Science and Technology, to play an integrative role across the whole of the Government (South Africa's National Research and Development Strategy 2002: 1). Thus far, South Africa has made significant progress in science, technology and innovation (Hanekom 2014: 1). The South African science and technology sector has grown stronger each year. Over the past decade research and development expenditure has grown fivefold, from R4 billion to R21 billion, which provides evidence for the successful implementation of the NRDS.

5.8.3 Ten-Year Innovation Plan (TYIP)

Scientific and technological innovations are crucial to developing a more competitive foothold in the global economy, and to addressing pressing developmental needs, although South Africa has yet to effectively mobilize innovation in support of economic growth. This 'innovation chasm' is a major weakness in our economy. Some progress has been made in this area, but it is universally agreed that the pace of progress is inadequate for South Africa's needs.

The TYIP was proposed to help drive South Africa's transformation toward a knowledge-based economy, in which economic growth is led by the production and dissemination of knowledge for the enrichment of all fields of human endeavour. The core projections of South Africa's innovation revolution must help to solve society's deep and pressing socio-economic challenges, which were summarized as South Africa's 'grand challenges' in science and technology. With innovation being the key to scientific and technological progress, South Africa's innovation revolution should contribute toward solving humanity's profound and persistent socio-economic tasks. As outlined by the DST (2008: 1), this is the Government's wide obligation, and the grand challenge of science and technology are in sync with the necessities of society.

Mangena (2009: 1) affirmed that "the South African science landscape has evolved dramatically since the dawn of democracy through the Government's commitment to transforming the inward-looking and embattled sector into a system that is innovative, flexible and responsive to the needs of society". South Africa's level of economic growth requires continual advances in technological innovation and the production of new knowledge. The country is optimistic that the TYIP will assist in meeting the focus on innovation. Hanekom (2014: 1) explained that South Africa and the rest of the BRICS countries are recognized as the future growth engines of the world economy, and is estimated that it will account for 50% of global gross domestic product (GDP) by 2020. Enhanced levels of technological integration into the global community will create huge opportunities for science, technology and innovation as critical growth and development drivers of the future (Hanekom 2014: 1). Thus far, many role players were involved in the TYIP. The perspectives on what the problem is and what constitutes its resolution differ across various societal groups. It is therefore difficult to ascertain whether the goals were achieved or not.

The DST's idea starts with the Government's wide socio-economic obligation, mainly the need to increase and endure fiscal progress, and is constructed on the base of the NSI. It recognizes the divide between South Africa and those countries acknowledged as knowledge-driven economies, such as Finland, Sweden, Denmark, the United States of America and the United Kingdom. To narrow the gap, the focus had to be on long-term goals covering South Africa's inability to commercialize the outcomes of scientific research.

The DST reported in their TYIP that the move to progress toward a knowledge-based economy will be driven by the following four elements (Department of Science and Technology 2007: 4):

- ❑ Human capital development.
- ❑ Knowledge generation and exploitation (Research and Development).
- ❑ Knowledge infrastructure.
- ❑ Enablers to address the 'Innovation chasm' between research results and socio-economic outcomes.

Improved investment in the aforementioned four key areas is expected to positively increase the commercialization of innovation. Furthermore, these elements will contribute towards the growth of national income derived from knowledge-based industries. South Africa's prospects for improved competitiveness and economic growth rely largely on science and technology. The knowledge-based economy has four pillars, namely: innovation, education, the economic and institutional regime, and information infrastructure. The four pillars were designed to stimulate multi-disciplinary thinking and to challenge researchers to answer existing questions, create new disciplines and develop new technologies (Department of Science and Technology 2007: 5). Nations that have achieved accelerated growth in outputs and capabilities have targeted investments in areas of strategic opportunity. It is anticipated that such investment will contribute to a more rapid economic and social transformation. By targeting development and new global industries, South Africa can reduce its dependence on imported technology, thereby resulting in a more self-sufficient country in basic commodities such as energy and food (Department of Science and Technology 2008: 6).

The key principle of the TYIP is built on the fact that South Africa's ability to translate innovation into economic growth is inadequate. While the Government participates throughout the complete innovation chain, strategic decisions must be taken. The DST, in collaboration with other Government departments, aims to boost innovation through a sequence of interventions in strategic areas such as chemistry, biology, earth sciences and nuclear sciences, coupled with advances in information technology. The DST have also identified that the key impediment to the commercialization of technological innovations is funding, owing to the high risk and complexity of R&D investments. Novel inspired funding mechanisms that could aid in addressing this challenge are evolving through public/private partnerships, such as university/industry collaborations. Such partnerships have the apparent ability to close the financing gap in becoming effective financing vehicles for medium/high-tech and high-tech innovations.

In this context, to address the disintegration of funding instruments the TYIP introduced the establishment of the Technology Innovation Agency (Department of Science and Technology 2009: 20). This agency incorporates, among others, the Innovation Fund which is aimed at projects of an innovative nature, with the potential to generate new knowledge and products of high commercial application.

5.9 Obligation under the IPR Act

The IPR Act 51 of 2008 was introduced by the South African Government. The Act established the NIPMO, which is tasked with ensuring compliance with the Act. The aim of the Act is to ensure that IP emanating from publicly financed R&D is identified, protected and commercialized for social, economic, military or any other benefit of the citizens of the country (Sibanda 2008: 1). The discussion that follows highlights the obligation of HEI's as recipients of publicly-financed research and development funds.

5.9.1 Obligations of Higher Education Institutions (HEIs)

The IPR Act regulates that publicly-financed institutions have in place an IP policy. Publicly-funded institutions have certain statutory obligations under the IPR Act. These include the establishment of an IP&TTO and the development and implementation of policies for the disclosure, identification, protection and commercialization of IP, which should include benefit-sharing arrangements (South Africa: Intellectual Property Rights Act 51 of 2008). All publicly-funded research institutions are obliged to adhere to the following (South Africa: Intellectual Property Rights Act 51 of 2008):

- Institutional IP&TTO's must be staffed by appropriately qualified personnel with expertise and interdisciplinary knowledge.
- Institutions must ensure that measures were implemented for the identification, protection and development of intellectual property. The correct management of

IP transactions are adhered to and where applicable, the commercialization of IP and appropriate capacity-building is implemented.

- Institutions must provide effective and practical measures for IP emanating from publicly-financed R&D, which must be appropriately protected before the results of such R&D are published or publicly disclosed.
- Researchers at publicly-financed institutions are obliged to disclose innovation to the institution's IP&TTO within 90 days of identification and prior to public disclosure. Public disclosure pertains to any form or medium made available to the public through publications, written or oral description, by use or any other way that would destroy the opportunity to apply for IP protection. Conventional academic publications such as abstracts, theses, dissertations, presentations and posters are all forms that constitute a public disclosure. Should results arising from research meet the criteria of novelty, a non-obvious inventive step and usefulness, the IP&TTO should therefore be informed to allow for a patent application to be filed.
- The IP&TTO must assess the IP to determine whether it merits statutory protection, and where appropriate make necessary application for its protection.
- Refer disclosures of IP for which it elects not to retain ownership or not to obtain statutory protection to the NIPMO within 30 days of it making such a decision.
- Institutions are obliged to manage revenue generated from IP transactions, which includes the management of benefit-sharing arrangements with innovators.
- Institutions are obliged to report to the NIPMO twice a year on all matters pertaining to the intellectual property contemplated in the IPR Act, including the status and the state of commercialization, furnishing reasons on IP not commercialized.

- Institutions are obliged to implement mechanisms to annually assess, record and report to the NIPMO on the benefits to society of publicly-financed research conducted at the institution.

While the IPR Act obliges the institution to include provisions within each of their IP policies, benefit-sharing can vary to suit individual institutions. Most institutions will claim ownership of IP developed by staff and students in the course and scope of their employment or studies. Although some institutions may exclude work produced by undergraduate students, they all will include research undertaken by post-graduate students. It is important that all researchers and innovators at publicly-funded institutions are familiar with the institution's IP policy. Should a project be funded by a private entity on a full cost basis, however, any IP developed that is deemed not publicly-financed shall therefore not be restricted by the provisions of the IPR Act. Full cost models differ at various institutions, but include all the direct and indirect costs of a project. All institutions have determined methods for the calculation of indirect costs, such details normally being available from the IP&TTO.

The IPR Act regulates that institutions obtain approval from the NIPMO when concluding certain IP transactions, for example the assignment of IP to a third party or off-shore exclusive licenses. When licensing IP, institutions are indulged to give preference of non-exclusive licensing to the local broad-based Black Economic Empowerment (BEE) and small and medium companies. Institutions are to ensure that the Government has an irrevocable, non-exclusive, royalty-free, worldwide license to use any IP for the health, security and emergency needs of South Africa. In addition, before granting an exclusive license to IP created from public funds, the institution must ensure that the licensee is capable of developing the IP further, and where necessary to undertake commercial activities (South Africa: Intellectual Property Rights Act 51 of 2008).

5.9.2 Benefit-sharing for innovators under the IPR Act

IP creators and their heirs at publicly-financed institutions are entitled to share in the benefit of successfully commercialized innovations. The benefit is subject to the institution's policy, in accordance with the minimum benefit as recommended by the IPR Act. In summary, the IP creator is entitled to 20% of the first R1 million of (gross) revenue accruing to the institution, and 30% of the net income thereafter. An example of income distribution is explained below (South Africa: Intellectual Property Rights Act 51 of 2008):

> In a transaction that has a single IP creator on an innovation that is successfully commercialized, the following rule will be effective (Southern African Research and Innovation Management Association 2013: 13):
>
> > The institution receives R2.5 million in royalty fees and spends R450 000 on patent costs. Under the IPR Act, the IP creator is entitled to a minimum of:
> >
> > > 20% of the first R1 million = R200 000
> > > 30% of R1.5 million less R450 000 = R315 000
> > > **Total received by IP creator = R515 000**

On the calculation of benefit-sharing the institution takes into account benefit that accrues to the institution, which includes non-monetary benefit such as shares in a company. The default position allows for the benefit to be shared equally amongst the inventors, unless it is agreed otherwise or the institutional IP policy states differently. As stated previously, it is important that researchers and innovators at publicly-funded institutions are familiar with the institution's IP policy.

5.10 Role of the Intellectual Property and Technology Transfer Office (IP&TTO)

Dedicated IP&TTO's have been set up by universities and research institutes globally. Some of these offices have successfully commercialized IP, which have been accompanied by financial rewards (Isis Innovation 2015: 2). According to Roessner (2009: 15) some universities elect not to engage directly in the commercial process, as such activity was viewed in theory as conceding their commitment to openness and knowledge dissemination. Roessner (2009: 15) further commented that many HEI's avoided IP issues, and the few that did become involved contracted out their patent management activity to third party organizations. In response to the IPRPFRD Act 51 of 2008, South African universities were required to set up IP&TTO's. The functions of an IP&TTO include: i) the identification of research output with potential commercial value; ii) ensuring that IP is protected for appropriate legal rights; iii) out-license research innovation to industry partners or set-up of a spin out company; and iv) advising the researcher of the IPR Act specifically for research that was financed by a Government funding agency (South Africa: Intellectual Property Rights Act 51 of 2008). The focus of these offices are to gain revenue to support university research, thereby enhancing economic development locally and internationally. Nelsen (2007: 538) advises that such offices are expensive to set up. Further amongst the ten points he outlined that heads of IP&TTO ought to know about setting up of on IP&TTO is that it may take several years for the office to stop losing money. He added that eventually the economic impact on the university can turn out extremely large and beneficial.

Potočnik (2012: 13) advised that innovators do contribute to the commercialization process, being the authority on the subject of a specific innovation being disclosed. This is supported by Isis Innovation (2015: 3) in stating that innovators working with the IP&TTO adds value and speeds up the commercialization process. It is recognized, however, that the central role and attention of the researcher is in research and teaching, and they are therefore faced with major time constraints. Commercialization is considered a time- consuming activity. Literature also reveals that the lack of researchers' involvement with commercial activity is attributed to the measurement of publication output and not by commercial activity. The IP&TTO therefore manages the commercialization process to free researchers to focus on their core strengths. Aside from reporting to the NIPMO, the IP&TTO function includes the registration of IP; checking on freedom to operate; negotiating license agreements; and seeking commercial opportunities such as spin-out formation and benefit-sharing to beneficiaries. Whilst some academics have the ability to perform such duties, most do not and often have time constraints.

The IP&TTO's have the potential to build ecosystems around universities which could potentially attract external funding for commercial application. With experience, IP&TTO's gain an understanding of the risky nature of the technology development business, thereby strengthening their efforts in commercial activity. This is reinforced by Isis Innovation (2015: 4) which stated that many IP&TTO's have gained experience, expertise, contacts and knowledge on the process of commercializing technologies from successful and unsuccessful attempts. Experience allows the IP&TTO's to foresee pitfalls that can guide academic researchers accordingly. University technology transfer is often described as a 'contact sport' and it is important for academics to have the support of experienced IP&TTO staff at the university (Isis Innovation 2015: 5). Most IP&TTO's provide a resource of trained and experienced professionals to give expert support to researchers and industry partners. Without the experience and expertise of an IP&TTO, innovation commercialization may prove to be less efficient, more expensive and less likely to result in a success.

5.11 Partnerships for commercialization of university innovation

To attain viable growth in specific areas, South Africa needs to drastically reinforce its human capital progress and knowledge generation (Department of Science and Technology 2008: 27). Mugabe (2009: 3) suggested that South Africa's existing institutional arrangement requires new knowledge on the effective transfer of technology to local institutions and industry. Rapid transfer of technology often requires funding, however, to make the process possible. Universities lack such funding, thereby negatively impacting on such processes. This is supported by Wessner (2012: 11), who attested that financing has been recognized as the main obstacle to innovation commercialization, and is found to be attributed to the high risk and complexity of R&D investments. According to the TIA's 2012/2013 Annual report, emerging public/private collaborations have the possible ability to assist in closing the funding gap, thereby becoming active financing mechanism for medium to high technology innovations. The TIA has therefore addressed the fragmentation by incorporating various funding instruments, such as the Innovation Fund and Seed Funding programmes. The establishment of network competence centers by the TIA focuses on market prospects in building toward a competitive edge for South Africa.

The Technology and Human Resources for Industry Programme (THRIP), which is funded by the South African Department of Trade and Industry (DTI), was also established. This partnership programme between government and the private sector was established in response to the absence of high-level technical expertise for industry and the requirement to expand the competitive edge of the South African industry through the expansion of innovative technologies. The goal is to enhance South African industry by supportive research and technology progress by augmenting the quality and quantity of suitably adept people. The THRIP brings together South Africa's researchers, academics and industry stakeholders in funding collaborations that enable innovators to improve the quality of products, service and innovation. The objectives of the THRIP are as follows (Technology and Human Resources for Industry Programme 2009: 1):

- To increase the number and quality of people with appropriate skills in the development and management of technology for industry.

- To promote increased interaction between academic researchers and technology managers in industry, universities and Science Engineering and Technology Institutions (SETI's), with the aim of developing skills for the commercial exploitation of science and technology.

- To promote the mobility of skilled people between industry, universities and SETI's with the aim of further developing researchers and R&D managers.

- To stimulate industry and the Government to increase their investment in research, technology development, technology diffusion, and the promotion of innovation.

- To promote increased collaboration between large and small enterprises, universities and SETI's by conducting R&D activities leading to technology transfer and product or process development.

- To promote thematic collaborative research and development projects within the National Industrial Policy Framework (NIPF).

- To steadily contribute to research outcomes that improve the quality of life for all South Africans.

Since its inception, the THRIP has become a 'powerful formula' for the stimulation of innovation leading to effectiveness and resulting in growth and development. This programme has extended co-operation between HEI's and industry by providing access to applied research performed at HEI's. Results of this collaborative partnerships have positively impacted on the cost-sharing benefit of research, with solutions towards competitive industry need being satisfied.

Another sustained programme for industrialized innovation is managed by the Industrial Development Corporation (IDC) on behalf of the DTI. The Support Programme for Industrial Innovation (SPII) is designed to stimulate and support technology expansion in industry through the delivery of financial assistance for projects that advance innovative products. The SPII is concentrated precisely at the segment that begins at the conclusion of basic research (proof of concept stage), and ends at the point where a pre-production prototype has been created.

Universities and industry are required to apply strategies to escalate collaborations and knowledge transfer, while adequate joint benefit can be achieved (van Zyl, Amadi-Echendu and Bothma 2007: 1). Van Zyl, Amadi-Echendu and Bothma (2007 cited in Yield 2007) further stated that the World Summit on Sustainable Development advocated that sustainable development rests on economic development; social development; and environmental protection, and therefore South African industries and universities are required to cultivate the scientific labour force (Department of Science and Technology 2009: 4). This infers superior levels of collaboration amongst all divisions of the Government, industry and HEI's. The complex manner in which innovation is transferred between a university and industry is a diverse process. Kenny (1986: 73) highlighted that partnerships between a university and industry are on the increase globally. The gap of innovation transfer between university and industry still persists in South Africa, however, a situation that requires attention for enhancement. This is supported by van Zyl, Amadi-Echendu and Bothma (2007: 2) who declared that a wide gap seems to exist in the expectations and perceptions of university and industry partners, probably as a result of a poor understanding of the knowledge transfer mechanisms in their R&D collaborations.

Universities are the main source of scientific innovation and are best positioned to solve societal problems, thereby making important contributions for the common good. Increased collaboration between HEI's and industry to meet innovation requirements will therefore result in a combined effort to compete in the global economy. The benefit of HEI's in drawing on the insight of experienced and skilled industry researchers with business and science backgrounds is crucial in their efforts towards commercial application.

5.12 Skills and human capital pipeline

The Department of Environmental Affairs (2009: 35) commented that mediation to address the South African knowledge worker encounter ought to be agreed in the context of the human capital 'pipeline' that begins with postgraduate students and result in world-class experts and researchers. The number and type of skills in areas such as engineering, technology and economic interface and innovation, needs to achieve the main objective of the DST's Ten-Year Innovation Plan, which is to enhance the number of patents and innovations (Department of Science and Technology 2008: 3). The DST stated that there is a need to focus on integrating innovation studies within the academic curriculum in South Africa. This should comprise of innovation and technology management; product growth; technology cultivation; and project and business management. Focus on the introduction of this type of rationale should be at all levels of tertiary study in science and engineering. In developed countries, such abilities emerge at specialist universities such as Stanford University and MIT in the USA. Should these considerations be implemented, it would yield a workforce with innovation talents that are required to contribute towards competitiveness.

Universities and the science councils can deliver a focal role in providing and encouraging innovation skills (Department of Science and Technology 2008: 30). The plan on educational courses in the field of basic and advanced innovation skills is correlated to a study by Oluput (2009: 209), who suggested that the root cause of insufficient funding stems from the lack of entrepreneurial abilities by universities. Oluput's (2009: 210) study recommended that HEI's implement strategies adopted from Manley (2004). This recommendation is to introduce training to provide students with business and science skills (Oluput and Maharaj 2012: 5). The curriculum design should develop critical thinking and multi-faceted team oriented skills to compete in the changing career landscape driven by innovation. The introduction of a Bachelor of Innovation Technology in Business Management (BITBM) would be in keeping with the Government's TYIP toward the skills shortage in South Africa. As done at Stanford University over three decades ago, an entrepreneurial mindset is required to be stimulated among academics and students in becoming future academic entrepreneurs (Brorstad 2009: 47). To recruit more academics into a research-based entrepreneurial programme, a much broader mobilization within academic institutions may be necessary.

Co-operation in the triple helix arena of the Government, industry and universities requires all three parties to refine their commercial skills to effect change in the South African science and technology landscape (van Zyl, Amadi-Echendu and Bothma 2007: 18). Increased collaboration between the university, industry and government sectors may contribute towards this effort. University researchers need to enhance and increase their research relevance to industry requirements through strategic selection of research areas and purpose. Journal publications must be relevant to both the university curriculum and industry needs. With enhanced interaction between universities and industry, universities will learn more of the industry requirements in relation to cutting edge research. This is reinforced by van Zyl (2007: 18) who argued that academics need to escalate the importance of research to industry by careful consideration of the focus selection, as well as the resolve, content and readability of the reports and articles they write.

Universities face the added challenge of access to experienced IP and commercialization experts. These professionals and skills sets are in short supply, which is often a result of government employment rules and pay-scales that prevent universities from being able to offer competitive salaries. The absence of entrepreneurial skills and experience at universities, results in the low rate and inability to successfully commercialize innovation.

5.13 Conclusion

The chapter provided an in-depth analysis of the South African higher education innovation landscape, together with the legislation that governs IPR's in the country. The role and functions of Government entities were highlighted. The review of relevant literature provided various possible reasons for the low rate of the commercialization of innovation in South Africa and the motivation to correct or better the current situation.

South African universities need to confront their failure to commercialize research results as a contribution towards the nation-building global and competitive economy (Kruss 2009: 4). According to the DST, the IPR Act was aptly positioned in light of public funding to emphasize the potential of IP in contributing to economic enrichment, wealth creation and social upliftment in research funded by the Government. The IPR Act ensures increased accountability regarding government funded research expenditure.

The Act awards innovators the right of ownership to IP, on the understanding that in the event that a recipient does not wish to retain such a right, the Government may acquire IP if it is of national interest. Motivation for IP creators at publicly-funded institutions to continue creativity and to disclose IP, in light of the benefit sharing guidelines as regulated by the IPR Act. Institutions and IP creators may further negotiate mutual benefit-sharing arrangements with individual institutions. Recipients of research funds have an obligation to ensure that IP is commercialized with the benefit flow to the citizens of the country.

The Act regulates the conditions to be met prior to assignment of IP to an off-shore party being concluded, in order to prevent the loss of IP to international jurisdiction.

The IPR Act enforced the establishment of the NIPMO to ensure the effective implementation of the Act through capacity development, advisory services, funding of IP costs, public rights and regulatory functions in terms of the Act.

Urgent attention is required to enhance innovation and growth in the identified priority sectors. The Government recognizes the potential of procurement to stimulate technological innovation. Regulatory frameworks in support of local innovation, including SMME's and technology start-ups, need to be nurtured. New mechanisms to monitor indicators such as patents, technology-trade mix, sector performance and technology balance of payments, need to be introduced. The DST has partnered with the provincial government to facilitate the development of regional innovation systems.

South Africa needs to enrich its knowledge to create a conducive milieu for the commercialization of innovation both locally and internationally. Evidence from the literature dictates that all knowledge-based markets are linked through an emergent international research and collaboration network. South Africa is required to reinforce its global partnerships and network to be able to be an equal competitor in the global markets.

Having focused on the evaluation of university commercialization of innovation in various countries internationally in previous chapters, the next chapter discusses the methodological design followed for this study.

Chapter 6

RESEARCH METHODOLOGY

6.1 Introduction

The literature reviewed in the previous three chapters provided an understanding of the commercialization of university innovation nationally and internationally. Du Plessis (2009: 1) affirmed that research is necessary due to the challenges in education. Bless, Higson-Smith and Kagee (2006: 1) stated that research is focused on defining a research question and thereafter finding a systematic way to find solutions to the research question. This chapter outlines the objectives of the study and provides an overview of the rationale for the choice of design that tests the acceptability of the results. The process utilized in the administration of the data collection instruments, the collection methods and the analysis thereof are presented herein. This chapter also provides insight into the need for ethical considerations and how they were maintained in the study. The sections that follow present the research methodology in relation to this study.

6.2 Research design

There are two approaches to research design, namely, qualitative and quantitative research. Creswell and Garrett (2008: 323) refer to mixed research methods as a means of collecting, analysing and using both qualitative and quantitative data within an established approach. The advantage of using mixed methods for research is the ease with which findings are reconciled (Hammond 2005: 240). Quantitative research is a formal, objective, systematic process in which numerical data is used to obtain information to describe variables; to examine relationships among variables; and to determine cause-and-effect interactions between variables (Burns and Grove 2005: 23).

Qualitative method of Research is primarily exploratory research. According to Wyse (2011:1) qualitative is utilized for understanding the fundamental motives, opinions, and motivations. This delivers understandings into the problem and assists in developing concepts or hypotheses for probable quantitative research. Qualitative information gathering techniques vary by means of unstructured or semi-structured methods. Common techniques include group dialogs, individual interviews, and observations. The sample size is characteristically small, and participants are carefully chosen to satisfy a specified quota.

Davies (2007: 205) states that the analysis of data in a multi-method study allows one to keep the findings separate, and to build on a cumulative portrait of one's subject. The mixed methodology was selected to conduct the investigation as to how universities can increase the rate of commercialization of university research. The research topic lent itself to the use of the mixed method for research as both qualitative and quantitative data excel at bringing an understanding of a complex issue or object; this extends experience or adds strength to what is already known through previous research. King and Horrocks (2010: 7) indicated that quantitative research is about measurement, where information about aspects of the world is captured accurately and is expressed in numbers which are represented in percentages, probability values and variation ratios. In the case of this study some of the data that was required could best be expressed in numbers so that appropriate conclusions could be drawn. It was also necessary, however, to obtain text data which allowed respondents to express themselves fully and completely. King and Horrocks (2010: 11) explained that theoretical principles are rooted in interpretivism, which is an interest in how the social world is experienced and understood. Interpretivism is more complex than it appears because people's interpretations of the same or similar facts and events may differ (King and Horrocks 2010: 11). Quantitative approaches might be too restrictive and not allow respondents to explore and express their responses optimally, whereas qualitative approaches make allowance for the subjective nature of a response.

There are sound reasons for the selected use of research design for this study, as both the quantitative and qualitative methods have limitations in data collection. Schulze (2003: 12) declared that quantitative research systematically overlooks critical features of human phenomena so that the results are often of limited value. Johnson and Onwuegbuzie (2004: 16) argued that both quantitative and qualitative methods are concerned with answering the questions of the research, although more in-depth research questions tend to be asked in qualitative research. The use of mixed methods can confirm the findings of the research and minimize the weaknesses of the two approaches (Creswell and Clark 2011: 155).

This study utilized a survey through structured questionnaires and semi–structured interviews session were utilized with Intellectual Property and Technology Transfer Office (IP&TTO) staff at the 23 universities in South Africa. Inventors were selected from universities with IP portfolios of commercialized and un-commercialized innovations for the interview sessions. According to Check and Schutt (2012: 11), quantitative and qualitative methodologies are frequently combined to enrich research, particularly in the education sector.

6.3 Population and sampling

Welman, Kruger and Mitchell (2005: 52) explained that the target population can consist of individuals, groups and organizations. For the purpose of this study, the IP&TTO managers at the 23 South African universities formed part of the target population which responded to the self-administered questionnaire. The remaining composition of the population was made up by innovators affiliated to the 23 universities. The selected innovators were creators of innovation to which patents are registered against the name of their affiliated university. The population is the entire set from which generalisations are made (Sapsford 2007: 6). This is complemented by Bless *et al.* (2006: 99) who stated that a clear definition of the population is important for generalisations to be made.

A source list (Annexure A) was obtained from the Department of Higher Education and Training (DHET) which indicated the total number of 23 South African universities identified at the time that the research study commenced in 2013. An electronic communication requesting consent to participate was forwarded to all university DVC's or Research Directors. Upon consent being granted, the prepared questionnaire was sent to the IP&TTO managers via electronic medium.

Maree (2003: 39) attested that convenience sampling, judgemental sampling, quota sampling and snowball sampling are non-probability sampling techniques. Purposive sampling is undertaken with a purpose in mind. Sampling simply means sampling without using random selection methods (Jones 2011: 17).

Census sampling is a complete enumeration, which means a complete count. In the case of this study, the structured questionnaire was administered to the IP&TTO managers at all 23 universities in South Africa which denotes full census sampling. When census sampling is utilized, the information provided can be used to draw conclusions on the total population; this method has a high degree of accuracy. According to Farooq (2013: 1) no other method is as accurate as census sampling when the population is this small. For the interview sessions, convenience sampling was utilized to determine interviewees at an innovators exhibition during January 2015. Each innovator was affiliated to one of the 23 universities. The exhibition was arranged by the Department of Science and Technology in an effort to promote the commercialization of university innovation. It was considered to be appropriate for the interview sessions to select innovators showcasing innovation to attract funding agencies, venture capitalists and investors at a common venue. A total number of 21 innovators were invited for an interview; seventeen innovators responded positively, however only thirteen interviews were carried out with success.

6.4 Data collection

In conducting this study both the primary and secondary sources of data were utilized to achieve the study objective. Primary data according to Saunders, Lewis and Thornhill (2003: 11) is usually collected through interviews and questionnaires. This is supported by Sharma (1995: 137) who stated that the personal method, the telephone interview or the mail survey are the various methods with which to collect data. Table 6.1 below reflects the criteria for the different methods of data collection.

Table 6.1 Criteria and data collection technique

NO	CRITERIA	PERSONAL METHOD	TELEPHONE METHOD	MAIL SURVEY
1	Cost	Most expensive	Intermediate	Least expensive
2	Speed	Slowest	Fastest	Intermediate
3	Accuracy	Most accurate	Least	Intermediate
4	Amount of data	Most	Least	Intermediate
5	Response rate	Highest	Intermediate	Lowest
6	flexibility	Most flexible	Intermediate	Least flexible
7	Control			
	❑ Sample	Intermediate	Worst	Best
	❑ Interview	Best	Intermediate	Worst
	❑ administration	Worst	intermediate	Best

(Adapted from Sharma 1995.)

As reflected in Table 6.1, the personal method of data collection provides many advantages. The highest response rate is generally achieved with the personal method of data collection and is considered to be the most accurate method. However, this method of collection is often not feasible due to the cost associated with the process. According to Sharma (1995: 137) and as depicted in Table 6.2, the telephone method is the least accurate and reflects the sample as the worst. Also, as reflected in Table 6.1, mailing the questionnaires proved to be the least expensive and the best with respect to administration. Willemse (2009: 15) attests when respondents remain anonymous, more open and honest responses are generated. Willemse (2009) further suggested that the convenience of the mailing method covers a wide geographical area, which is supported by Maree (2003: 49) who emphasized that the advantage of the mail survey is an increase in sample realization.

Primary data is information collected from sources such as personal interviews, questionnaires and surveys with a specific intention and on a specific subject, which is assessed and reported on by the researcher. Primary data is best collected when the researcher is directly involved in the empirical investigation and field work. A questionnaire is considered one of the main primary data collection instruments for research methods. Modes of data collection vary in the method of contacting the respondents, in the vehicle of delivering of the questionnaire, and in the way in which questions are administered. These variations can have different effects on the accuracy and quality of the data obtained (Bowler 2013: 1). A self-administered structured questionnaire was one of the instruments used to collect primary data from the IP&TTO managers at the 23 universities in South Africa. The second instrument used in the collection of primary data was the use of a semi-structured interview schedule for interviews carried out with innovators. Innovators with registered IP of commercial potential were interviewed at an innovation exhibition.

Yin (1994: 80) is of the view that no single source has a complete advantage over all the others. The mailing method was therefore utilized to distribute the questionnaire to the 23 universities, which are based in different provinces across South Africa. As indicated by Sharma (1995: 137) the personal method of data collection has been proven to have the highest and most accurate response rate, which led the researcher to conduct each interview personally. Secondary data was obtained from the review of relevant books, journal articles, internet documents and legislation.

For the purpose of this study, the structured questionnaire (Annexure C) was utilized to collect a portion of the primary data. The remaining portion of data was obtained through the use of a semi-structured interview schedule (Annexure D). The distribution of the questionnaires was effected via electronic mail. On completion of the questionnaire, the respondents submitted their responses via e-mail or facsimile. In the case of data collection for the interview session, the researcher considered it necessary to personally conduct all interview sessions. Responses during the interview sessions were recorded directly onto the interview schedule. Each recorded response was only captured by the interviewer once the response was verified by the interviewee as correctly implied.

An electronic communication (Annexure B) requesting approval to conduct the study was obtained from the DVC or Research Director at each of the 23 universities. Upon consent being granted, was the questionnaire (Annexure C) dispatched to each IP&TTO manager via email. Bowling (2013: 3) confirmed that modes of data collection by questionnaire differ in several ways, including the method of contacting respondents, the medium of delivering the questionnaire to respondents, and the administration of the questionnaire. These factors are likely to have different effects on the quality of the data collected. The questionnaire was therefore e-mailed directly to each of the 23 participating university IP&TTO managers. The census sampling technique was utilized, based on the IP&TTO

managers were believed to have the experience, knowledge and background to complete the survey.

Cohen and Walsh (2007: 116) explained that certain measures should be undertaken to ensure or avoid the non-return of questionnaires. Response dates were therefore set and reminders were sent out to alert respondents to the expected response date. An extension to the initial response date was then communicated to the IP&TTO managers whom had not yet responded. Subsequently a 2nd and 3rd reminder was sent before the final cut-off date.

A total of 21 completed questionnaire responses were received. Upon scrutiny, it was however discovered that some of the respondents had left one or two questions blank. Sekaran (2003: 303) refers to this as item non-response, which were left out of the statistical analysis, so there are some variation in the number of responses to each question. Statistics were obtained on the number of successfully and unsuccessfully commercialized innovations, including the present status of innovation at the time of the study and possible reasons for its status.

6.4.1 Design of data collection instruments

Willemese (2009: 15) advised that a good questionnaire should have at least three parts, namely, an administrative part, a classification part and subject matter of inquiry. Similarly, the devised structured questionnaire and the semi-structured interview schedule for this study included all three parts mentioned (within sections A to H accordingly). The questionnaire and interview schedule comprised of both open-ended and closed-ended questions. According to Maree (2003: 108) the characteristics of any standardized measuring instrument must be valid, objective, suitable and feasible. These collection instruments were designed around the objectives of the study and the review of literature. Each objective was used as a guide in the formulation of the questions. Both the questionnaire and interview schedule comprised of eight sections which consisted of:

a) Biographical data; b) Awareness of IP legislation and IP policy; c) University commercialization environment; d) Management of commercialization activities; e) Status of registered patents; f) Early stage financing and venture capital; g) Industrial linkages; and h) General views. The researcher intentionally covered the exact same sections in the questionnaire and the interview schedule so as to again a fair analysis of perceptions and responses from both the IP&TTO managers and the innovators. The election to design both instruments covering similar question further contributed to the validity and reliably of the study. By doing this a comparison between IP&TTO manager and innovator responses contributed to the rich analysis from which conclusion were drawn.

6.5 Pilot test

According to Dane (2011: 228) a pilot study is defined as the administering of the research instrument under special conditions before the actual survey is undertaken. Griffin (2005: 1) maintained that Cronbach's Alpha measures internal consistency. Griffin (2005: 1) argued that it is necessary to determine the reliability of collection instruments. This is supported by Dane (2011: 227), who claimed that the pilot study test is a crucial step in survey research.

Fowler (2009: 124) explains that with the self-administered questionnaire, problems that the respondents may encounter are less evident. In the case of interview sessions, interviewer can assist with any misunderstanding during the interview. The interviewer has a chance to rephrase a question while guarding against steering the interviewee's response in any particular direction. Dane (2011: 228) emphasized that the importance of the pilot study is the opportunity to amend the research instruments, thus avoiding any form of misunderstanding or bias. It has also been well documented that the pilot test of a research instrument predominantly increases the reliability, validity and practicability of the research (Blanche and Durrheim 2002: 11; Cohen and Walsh 2007: 32; Johnson and Christensen 2012: 26). The investment of time in conducting a pilot study is inferred to enhance the quality of the study by minimizing the possibility of unreliable results.

The questionnaire was tested with a homogenous group of ten IP&TTO staff at selected universities that were not included in the main sample of IP&TTO managers. The pilot test ensured that the questionnaire was clear, unambiguous and capable of soliciting responses that could be analysed. In the case of this study the researcher discovered that there were ambiguities identified with the questionnaire. Feedback obtained from the pilot test was incorporated to refine the questionnaire, so that the ambiguities were eliminated. The pre-test also revealed that the questionnaire was going to yield interesting and substantial data from the participants. The researcher ensured that the respondents understood the questions implicitly thereby generating trusted, reliable and accurate responses.

6.6 Semi-structured interviews

According to King and Horrocks (2010: 1) interviews are the most common method of carrying out a survey. Interviews are best described as the exchange of views between two people (Kvale 2007: 5). The interviews were personally arranged and conducted by the researcher with selected innovators from the affiliated universities. Researchers with registered IP with the potential of commercialization were interviewed at an innovation exhibition utilizing the prepared semi-structured interview schedule. King and Horrocks (2010: 42) believe that the physical space impacts greatly on the outcome of interviews, therefore it should be a private, quiet and comfortable environment. The researcher ensured that the environment was conducive for each interview session. The average duration of the interviews was 1 hour and 30 minutes.

The semi-structured interview schedules utilized allowed for flexibility. The responses were captured directly onto the interview schedules. This technique was found to be the recommended and suitable method to gather data for the study at hand. The schedule was designed around the themes that initially defined the research topic but allowed for divergence (Whiting 2008: 7). This design enabled questions to emerge from the dialogue and there was no obligation to pursue the pre-planned questions if it was not relevant to the participant (Whiting 2008: 7). The flexible nature of the semi-structured interview was important for the investigation of the research question because it allowed for unexpected topics to be raised. At the end of each interview session, the respondent was requested to verify that the implied response was correctly captured on the schedule.

The innovators were interviewed at an innovation exhibition during January 2015, which had been arranged by the Department of Science and Technology to promote university innovations. This implies convenience sampling, as the name implies the collection of data from members of a population who are conveniently available to provide the data that is sought. Questions were presented to the innovators to gain information regarding status of innovation; funding opportunities; attempts made to commercialize; and the manner in which innovations were managed at their respective universities.

The original interview schedule, for example, enquired about challenges that were experienced when attempting to commercialize innovations. After interviewing the first three innovators it became clear that they experienced three primary challenges: i) accessing early stage seed funds; ii) the IP&TTO staff lacked knowledge and experience in commercialization; and the perception that commercialization was not a high priority with university senior management. Although the original questions remained on the semi-structured interview schedule, it was followed up with questions regarding the three primary challenges identified by previous participants. Incorporating the knowledge gained from previous innovators fostered more in-depth discussions with future innovators. A copy of the semi-structured interview schedule is provided as Annexure D.

6.7 Anonymity and confidentiality

The anonymity and confidentiality of participants are central to ethical research practice. The researcher assured participants that the data provided would not be traced back to them in reports, presentations or other forms of dissemination, thereby respecting their preference to remain anonymous. Anonymity of respondents meant that the research instrument did not solicit identifying information of individual subjects, for example names, addresses and e-mail addresses. Maintaining confidentiality of information obtained from research participants meant that the researcher made every effort to prevent anyone outside of the research project from connecting individual subjects with their responses. The data was only accessible to the researcher and the research supervisors. The data will be destroyed after a five year period.

6.8 Ethical considerations

Silverman (2010: 155) indicated that “research participants must participate in a voluntary way, free from coercion. Consent has to be freely given for the research to be valid”. This condition was guaranteed as part of the process of securing ethical clearance. The first contact with each HEI was to obtain consent for their participation in the study from either the DVC or Research Director. The communication (Appendix B) included a covering letter outlining the proposed study with a request for their participation. On receiving approval from the relevant university management, each IP&TTO manager was sent the covering letter outlining the study that included the consent form that was approved by the Durban University of Technology Research Director. Throughout the study the researcher ensured that the participant's integrity was respected. The researcher complied with the ethical requirements of the Durban University of Technology.

Each participant, which in the case of this study was each university IP&TTO manager, was fully informed that participation was voluntary and that each participant was free to withdraw gatekeeper permission for this project to take place at that university at any stage, without giving reasons and without prejudice or any consequences. They were also given the assurance that information provided would only be used for research purposes and would be aggregated with other responses. Further, only the overall or average information would be utilized.

6.9 Data analysis

According to Sekaran (2003: 301) collating data, handling blank responses, coding, categorizing data files and programming precedes data analysis. Furthermore, Maree (2003: 90) explained that statistical techniques can be classified under two broad headings: descriptive statistics and inferential statistics. A comparative analysis was done between the results obtained from the questionnaires and interview sessions. Probability theories are used to quantify uncertainties about the conclusions that were generalized (Maree 2003: 90). Angrist, Imbens and Rubin (2005: 149) asserted that robust tools of appropriate parametric tests should be applied to test the hypotheses. Once the data had been collected, the researcher established the possible themes that arose from the quantitative data. The data was converted into a format that accommodated computer analysis (Cresswell and Clark 2011: 129). The data of each response was captured on a spreadsheet to form the composite data set. Codes were assigned to the responses to ensure accurate analysis and to minimise errors (Cresswell and Clark 2011: 128). The analysis was conducted with the assistance of computer software (SPSS, version 21.0). This enabled the researcher to analyse data and present the findings in the most convenient format.

Boyds (2010: 3) indicated that no general consensus exists amongst qualitative researchers concerning the process of data analysis. Rather, what exists is a plurality of analyses and interpretations which reflect the particular theoretical perspective or tradition within which the researcher is working (McKerchar 2011: 16). Many of the qualitative method text books, however, do attempt to identify some general features that are common to the analytical phase of qualitative research. The qualitative aspects of the interview responses were analysed by the researcher. Common themes were identified and analysed. For the purpose of this study the following steps were undertaken in analyzing the qualitative data:

- reviewed of all the responses to gain an initial sense of the data;
- organized data into a manageable form which included 'reducing the data', by developing codes (Boyds 2010: 6);
- interpreting the data, and
- presenting the data in some instances in the form of graphs, and others in the form of descriptive analyses.

Ritchie, Spencer and O'Connor (2003: 219) highlighted that the theoretical approach which informs a piece of qualitative research will essentially determine the process by which the data is to be analyzed. Interpreting the data in order to derive some theoretical framework or working hypothesis, proposition, or essence of the social processes under investigation (Boyds 2010: 9).

The first step in managing the process of coding in qualitative research is the linking of those elements of data that are conceived as sharing some perceived commonality.

According to Boyds (2010: 11), this process of coding can all too often implicitly reflect the researcher's (pre-) conceptualizations of the social phenomena under investigation. Hence the first step in avoiding such opaqueness in the process of data analysis is therefore not to confuse coding with developing conceptual themes (Conerly 2010: 27).

All interview responses were recorded on the schedule and analyzed using the method of thematic analysis in order to identify, analyze and report patterns within the data (Braun and Clarke 2006: 97). Probability theory was used to quantify uncertainties about the conclusions that were generalized (Maree 2003: 90). Common themes from the questionnaire and interview responses were identified. Thereafter, a comparative analysis was undertaken between the results obtained from the questionnaires, interview schedules and the literature review. This method of analysis has the advantage of being flexible as it can be applied across a range of theoretical approaches and paradigms. It can also provide a rich and detailed account of the data (Braun and Clarke 2006: 97). This approach allows for themes to be derived across a large number of cases and diverse data set (transcripts). The quantitative aspects from the questionnaire and interview responses, were coded, analyzed and represented by means of graphs.

6.10 Validity and reliability

Literature identifies two principle categories of challenge to research credibility:

- Validity, or *"… the extent to which the data collected truly reflect the phenomenon being studied"* (Ticehurst and Veal 2000: 23).

- Reliability, or "… the extent to which research findings would be the same if the research were to be repeated at a later date, or with a different sample of subjects" (Ticehurst and Veal 2000: 24).

While validity clearly applies to research methods involving positivistic elements (for example, are survey instruments designed so that they collected the data claimed?) (Yin 1994: 17). Silverman (2013: 210) posited that another word for validity is truth, and interpretation takes place even when using hard quantitative measures. Sekaran (2003: 21) contended that validity refers to the evidence that the instrument, technique or process used to measure a concept does indeed measure the intended concept. In terms of the internal and external validity, the researcher is concerned about the issue of the authenticity of the cause-and-effect relationship (internal validity) and their generalizability to the external environment (Sekaran 2003: 27).

Saunders *et al.* (2003: 11) espoused that reliability is the degree to which the data collection method(s) yield consistent findings such that similar observations would be made or conclusions reached by other researchers, or there is transparency in how sense was made from the raw data. The researcher's questionnaire and interview schedule was designed and pre-tested to ensure that the questions were clear to the respondents and that it yielded results relevant to the research objectives. The vocabulary chosen for the questions reflected terminology in use in the university sector and found in relevant literature. This ensured that the responses from participating HEIs were consistent. Care was taken to ensure that the instructions for the completion of the survey were clear and unambiguous. The interview schedule and the questionnaire were piloted with ten innovators (who were not part of the main sample) at the DUT to test for the clarity and interpretation of questions to ensure consistency. Vithal and Jansen (2003: 33) further attested that since the world of research with human subjects is not perfect, researchers developed a number of techniques for the estimation of reliability, i.e. the degree of error in measurement. One such technique is referred to as the reliability coefficient, a measure which ranges from r = o to r = 1 (perfect reliability). The higher the correlation coefficient (i.e. the closer to 1), the higher the reliability of the measure and the lower the error of measurement.

Maree (2003: 218) highlighted that the following factors threaten the validity of a measuring instrument (questionnaire) and that researchers should take cognizance of these factors, which include:

- If the instrument is not reliable, then it cannot be valid.
- Some respondents may tend to agree to all questions.
- Socially desirable responses – respondents answer in the manner they perceive or think is expected as desirable.
- Politically correct responses.
- The time of administering the questionnaire, for example, during the afternoon the respondent may be fatigued.

6.11 Limitations of the study

Although this study provides important insight into the commercialization of university innovation, a limitation of the study was that the sample of 23 universities being considered a small sample, of which only 21 universities participated. Further, a few innovators whom had other licensed patents to establish companies refused to be interviewed, as they feared that their projects would become known to other parties. In addition, many of the innovators were too busy, and with time constraints could not be interviewed. Thus, the data presented in this paper from the interview session was limited to those willing to be interviewed and not randomly selected.

6.12 Conclusion

This chapter detailed the research design in terms of the theoretical and methodological approaches used in this research. The main objective of this study was to address the research objective of commercialization of university innovation in South Africa. The research design and methodology section of the chapter reviewed the following methodologies and research techniques and tools:

- Research methods, such as quantitative and qualitative.
- Sources of information, being primary or secondary.
- Survey techniques, such as questionnaires.
- Data analysis tools, such as descriptive and inferential statistics.

This study utilized both the quantitative and qualitative research methods, questionnaires for the pilot and principal studies, and descriptive and inferential statistics. Each aspect of the study and the way in which the process was undertaken was explained, and is illustrated in Figure 6.1 that follows:

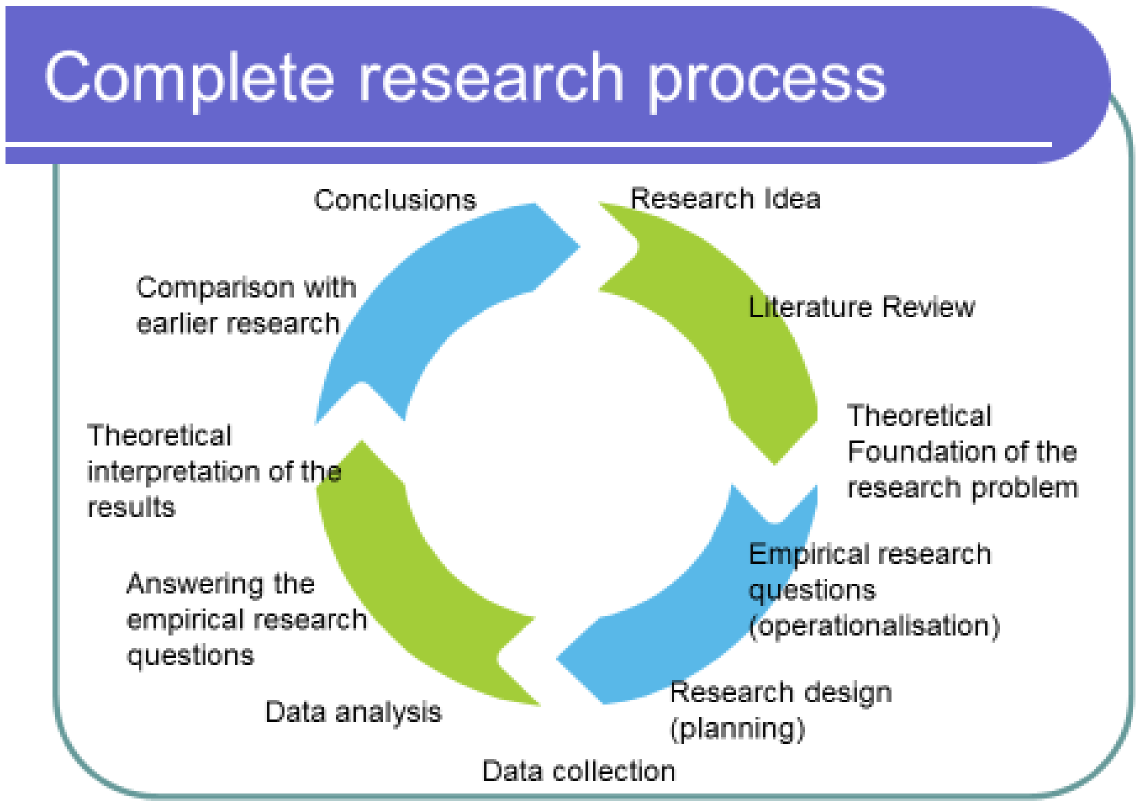

Figure 6.1 Complete research process (adapted from EPs Oxfordshire Training 2010).

The data collection and data analysis methods for the study were guided by the nature of the subject matter that was researched. In the first phase, data was obtained from IP&TTO staff at the 23 universities through the use of the structured questionnaire, which contributed towards the quantitative and qualitative data. In the second phase the semi-structured interview session was the method utilized to collect data from the selected innovators. The interview sessions contributed towards the qualitative data. Statistical analysis techniques were used to interpret the responses obtained from the interview sessions.

The visual presentation of the process for the sequential explanatory mixed methods design for this study is illustrated in Figure 6.1 above. Each of the eleven steps as outlined in figure 6.1 was carried out for the successful completion of the study. The chapter also outlined the measures that were observed to enhance the quality of the research study.

The next chapter discusses the findings of the study. Data retrieved from each university questionnaire and the interview sessions permitted the researcher to draw conclusions regarding the key areas under consideration. Based on the findings, conclusions are drawn and recommendations are made in Chapter 9.

Chapter 7

RESULTS AND ANALYSIS OF DATA

7.1 Introduction

Chapter 6 outlined the methodology for this research study. This chapter reports on an empirical study that was undertaken across South African universities. A questionnaire and a semi-structured interview schedule were the two instruments utilized for the study. The objective of the study was to gain an understanding of the commercialization of innovation activity at universities in South Africa. The focus was firstly to determine the nature and extent of the gap between university research and innovation commercialization. Secondly, to determine the causes of the apparent gap, with particular attention to funding constraints and the alleged lack of an entrepreneurial culture at South African universities.

The main questionnaire (included as Appendix C) was distributed to the IP&TTO managers at the 23 universities in South Africa during May 2013. Responses were received from 21 universities. The questionnaire was designed with due consideration to the objectives of the study, as highlighted in Chapter 6. An innovation exhibition arranged by the Department of Science and Technology (February 2015) was used to provide a second set of data from a sample of innovators. These were derived using a semi-structured schedule, which is included as Appendix D. A total of 22 innovators who were in possession of registered IP with commercial potential were invited for an interview. Seventeen responded, however only thirteen interviews were successfully completed. These interviews are analysed in chapter 8.

The data collected from the questionnaire and interview schedules was analysed using SPSS version 21.0. Descriptive statistics are presented in the form of graphs, cross tabulations and other figures for the qualitative data that were collected. Where possible, the findings reported in this chapter are linked to the review of literature in chapters 2, 3, 4 and 5.

The questionnaire was comprised of 41 questions with a level of measurement at a nominal or an ordinal level. The questionnaire was made up of a combination of pre-coded questions on a 4 and 5 level Likert scale, plus open-ended questions. The semi-structured interview schedule consisted of 24 questions. Both the questionnaire and the interview schedule were divided into eight sections which measured various themes as illustrated below:

SECTION A	**-**	**Biographical data**
SECTION B	**-**	**Awareness of IP legislation and IP policy**
SECTION C	**-**	**University commercialization environment**
SECTION D	**-**	**Management of commercialization activities**
SECTION E	**-**	**Status of registered patents**
SECTION F	**-**	**Early stage financing and venture capital**
SECTION G	**-**	**Industrial linkages**
SECTION H	**-**	**General views**

7.2 Reliability and validity

The two most important aspects of precision when generating data are reliability and validity (Bless, Higson-Smith and Kagee 2006: 156). Reliability refers to the assurance that the research would, if repeated, present the same results (Bless, Higson-Smith and Kagee 2006: 156). Validity means that the researcher checks the accuracy of the findings by employing certain procedures (Creswell 2014: 201). A reliability coefficient of 0.70 or higher is considered as ‘acceptable’. Two research techniques were used in this study (self-administered questionnaire and interviews) to collect data so that the validity of the study would be enhanced. Reliability and validity were discussed more extensively in the methodology chapter (Chapter 6).

Construct validity is the appropriateness of inferences made on the basis of observations or measurements (often test scores), specifically whether a test measures the intended construct. Methods used in the plan of this study to curtail risks to construct validity include:

- Utilizing several sources of evidence including a structured questionnaire; semi-structured schedule for in-depth interview; public information available from the case study entities; government and other reliable reports; and a large body of literature relevant to the topic.

- Maintaining a chain of evidence between the original material, the data descriptions, and then to the analysis of the data.

- Allowing the review by interviewees of each transcript description prepared by the researcher, so that each transcript description is valid.

Reliability of the results was ensured by compiling an extensive database, which included data from the transcripts of the questionnaire and the interviews. All interview transcripts were reviewed by the interviewees to be accepted as correctly documented prior to being transcribed onto Excel spreadsheets. This was done to ensure that the approaches were reliable, consistent and stable, as suggested by Yin

(2009: 32) that the qualitative researcher needs to fully document all steps of the research procedure. Each transcript was analyzed for common themes and to make sure that they did not contain obvious mistakes. Themes were identified, codes were allocated and data was compared for definition and coding. The approach used in this study permits the results to be generalized. They may not be applicable completely and uncritically, however, because of the different operating structures, framework and philosophical environments relevant to individual universities.

7.3 Presentation and analysis of results

SECTION A – Biographical data

This section presents the descriptive statistics based on the biographical characteristics of the respondents and their respective universities of this study. The information is described using methods that include graphical representations and cross tabulations.

7.3.1 Question One: Type of university

Fifteen of the respondents were from traditional academic universities whilst the remaining six were from Universities of Technology. Based on the Department of Higher Education and Training (DHET) categorisations, six of the 23 universities are Universities of Technology while the remaining 17 of the target population are traditional academic universities.

7.3.2 Question Two: Highest qualifications of respondents

This question enquired about the highest level of educational qualification of the IP&TTO managers who responded to the survey.

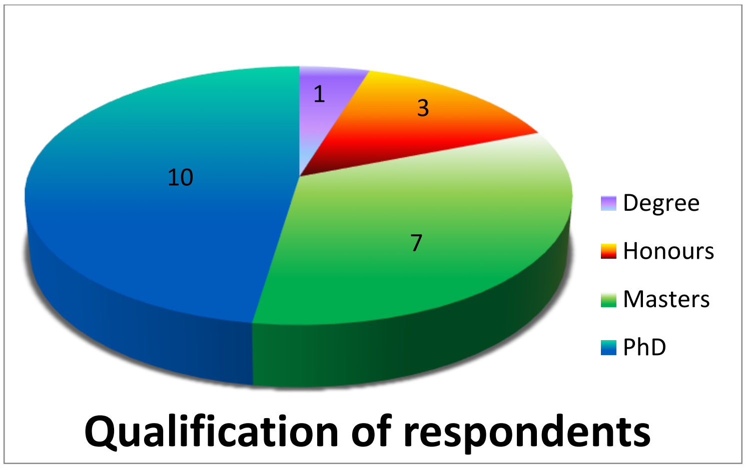

Figure 7.1: Qualifications of respondents

It was considered important to establish the respondent's qualifications, as the level of education has a direct proportionality to the in-depth understanding of commercialization activities (Baxter 2011: 16). It was established that only one respondent did not have a post-graduate Degree, while three of the participants were in possession of an Honours degree. As presented in Figure 7.1 above, seven were in possession of a Master's qualifications and the remaining 10 were in possession of a PhD qualification. A total of seventeen of the IP&TTO managers in this study are in possession of a PhD or Master's qualification.

7.3.3 Question Three: The number of years of experience in the field of IP and commercialization activities.

This question was intended to establish the experience of respondents in the specific field of IP and commercialization activities, in order to test whether there was a relationship between this experience and success in commercialization.

Fourteen of the respondents had between one and five years of experience in the field of IP and commercialization, while the remaining seven respondents have between six and ten years of experience in the field. Years of experience is considered relevant as experience in the field of IP and commercialization activities potentially adds value to the manner in which respondents view IP related activities from an experience perception. The apparent scarcity of IPR specialists devoted to commercialization activities stems from the discipline not being taught within university programmes; the only way to specialize in this field is though experience while learning on the job (Bradley 2009: 112).

It will be recalled (see section 5.10) that one important factor universities need to know about the setting up of an IP&TTO is that commercialization is a talent-based business (Nelsen 2007: 538). One should not underestimate the combination and level of skills required for an IP&TTO (Nelsen 2007: 538). It is apparently difficult to find people who can speak the two languages of academia and industry, and who also possess the creativity to craft agreements that meet the needs of both sides. According to Artelsmair, Ignaczak and Nauche (2008: 2), better patent-related services will be offered at universities which employ high-quality, customer-oriented specialists who provide services which link researchers with industry needs that in-turn increases the patenting of university innovations. Both Nelsen (2007: 538) and Artelsmair, Ignaczak and Nauche (2008: 2) postulated that better patent-related services offered to universities will increase the patenting rate, and that this can be achieved by a university focus on employing IP&TTO staff with a high level of experience and qualifications.

7.3.4 Question Four: Numbers of years the university IP&TTO has been in existence?

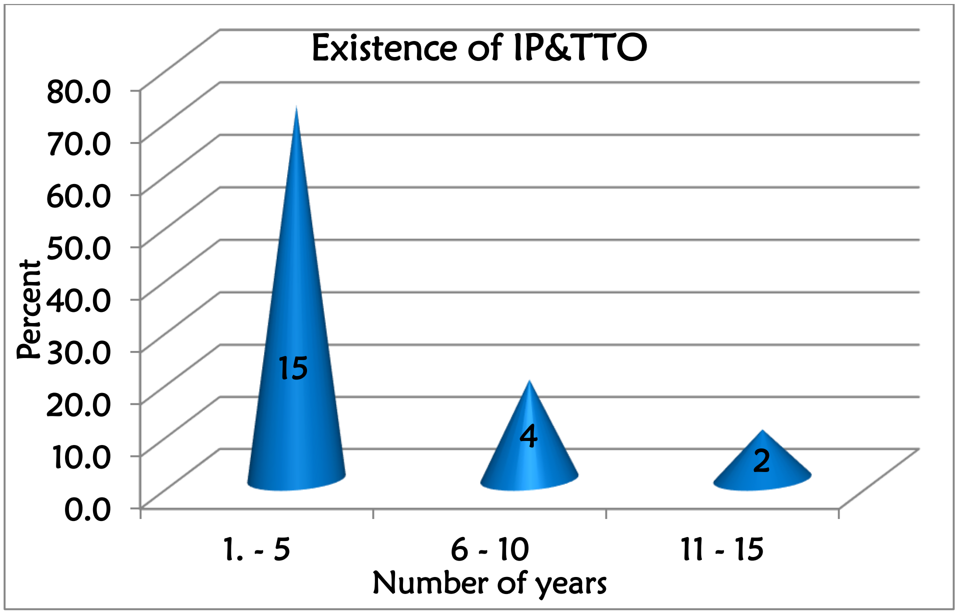

Figure 7.2: Existence of university IP&TTO.

The majority (fifteen) of university IP&TTO's had been in existence for less than five years. Only two of the universities had their IP&TTO's in existence between eleven to fifteen years, while the remaining four had been in existence between six and ten years.

Commercialization an indispensable component to a university nurturing an entrepreneurial culture is the technology transfer office. Establishing a successful technology transfer process in a university setting requires consistent, in-depth levels of training, mentoring and education. The IPR Act 51 of 2008 attributed to the establishment of a large number of IP&TTO's within five years of the enactment. The Act was accompanied by a mandate from Government as stipulated in Section 6(1)a of the Act that, “unless determined otherwise by the Minister in consultation with the Minister responsible for higher education, or any other Cabinet minister to which an institution reports, all institution must, within 12 months of the coming into effect of the Act, establish and maintain an office of technology transfer”.

There is an association between the time a university has been engaged in commercial activity (the age of the IP&TTO) and the success of the university in commercialization. In the USA there is a relationship between the length of time that a university has had an IP&TTO and the commercialization outcomes conveyed to the Association of University Technology Managers (AUTM): the older the IP&TTO, the greater the results achieved. It should be noted that many of the older IP&TTO’s were recognized before the Bayh-Dole Act, including those at universities such as Stanford and MIT, with impressive track records of achievement in commercialization.

7.3.5 Question Five: The number of staff employed at university IP&TTO?

Nineteen of the universities employed between one and five staff members at the IP&TTO. The remaining two universities employed between six and ten members of staff. According to Sibanda (2009) and Alessandrini *et al.* (2013: 6) this is considerably less than the 8.7 average at European universities. Further evidence reported by Rasmussen (2008: 511), found that Canadian university IP&TTO’s employ between one and 30 persons.

It is highly likely that the commercialization of university innovation forms the basis of spin-off creation which requires skilled and highly trained commercialization staff to develop spin-off companies (Earl and Gault 2008: 27). The literature reveals that the main barrier to the development of IP&TTO’s is access to experienced professionals (see section 3.6.2), and that the skill sets of such professionals is in short supply. An even arger stumbling block can be employment rules and the pay-scales of Government, which prevents universities from being able to provide competitive salaries to skilled and experienced professionals. Governments in certain countries are attempting to assist universities build IP management capacity. National patent offices are also involved in providing training in IP related activities to universities.

SECTION B - Awareness of IP legislation and IP policy

Section B relates to the Intellectual Property Rights Act.

The focus of the Intellectual Property Rights Act is as follows: If a researcher has conducted research with publicly financed funding, the ownership of the intellectual property produced from such research resides with the HE institution.

Questions 6, 7 and 8 where formulated to enquire on the ownership provisions of the Act. The levels of disagreement (negative statements) are collapsed to show a single category of disagreement. A similar procedure is followed for the levels of agreement (positive statements).

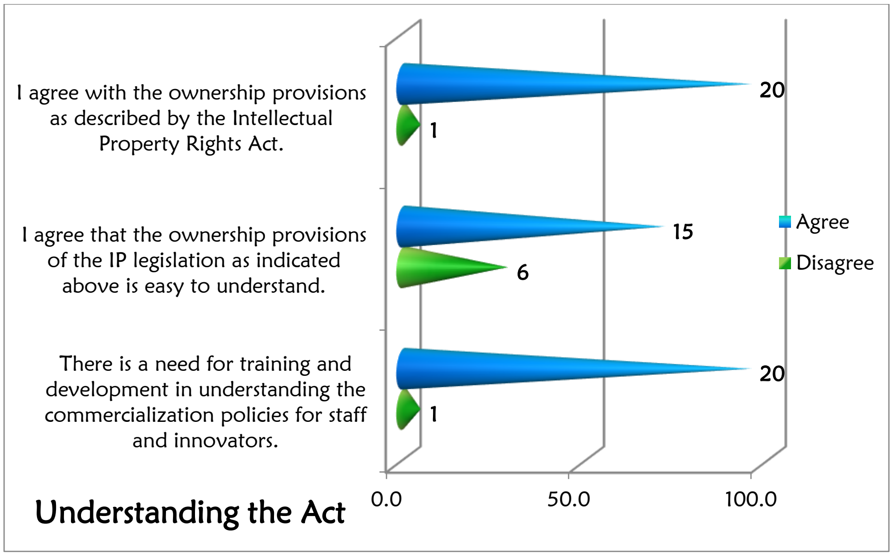

Figure 7.3: Statements with reference to the Act.

7.3.6 Question 6: Agreement with ownership provisions of the IP legislation

A total of 20 of respondents agreed with the ownership provisions of the Intellectual Property Act, while only one of the respondent disagreed. The IPR Act (see section 5.6.1) recognizes that HEI's are beneficiaries of public funds, therefore ownership of the intellectual property produced from such research resides with the HEI.

According to Cervantes (2011: 3) "In Canada, where rules on IP ownership by universities vary across provinces, efforts have nevertheless been made to harmonize policies at least with respect to R&D funded by federal government". In countries such as Ireland and France, in some instances universities retain ownership. Governments of those countries have elected an alternate path as regulating guidelines for the management of IP that foster consistent practices. China has made legislative reforms that allow universities to claim IP, however the implementation of such changes remains a challenge (Zhao 2011: 2). Although each country's focus is on the importance of innovation commercialization, Wessner (2012: 1) advised that the different national systems require solutions suited to each country's environment.

7.3.7 Question 7: Understanding of the IP legislation

A large number of respondents (fifteen) felt that the IPR Act was easy to understand, but the remaining six respondents felt it was not. For the efficient functioning of an IP&TTO it is obviously imperative that the IP legislation is clearly understood. Baxter (2011: 32) stated that the success of innovation commercialization stems from a good understanding of the legislation that governs that particular intellectual property. This is supported by Sushil (2009: 15), who stated that a commercialization strategy rests on different variables such as specific conditions; commercial ability; viable environment; and more importantly, the country's legislation.

7.3.8 Question 8: Training and development in understanding of commercialization policies

A large number of respondents (20) agreed that there was a need for training and development in the understanding of commercialization policies. Only one of the respondents disagreed. The high levels could be attributed to a sense of ambiguity and uncertainty regarding the Act's practical application, warranting the feeling that the Act requires re-drafting. Indeed Wits Enterprise (2012) has noted that certain sections in the Regulations are inconsistent with the provisions of the Act. In order to clarify areas of uncertainty in the Act and Regulations, the regulator has published guidelines. Practice notes, similar to those deployed on tax matters by the South African Revenue Service, have been proposed as a tool.

SECTION C - University Commercialization Environment

This section deals with the awareness of the legislation or statutory guidelines in relation to IP in the commercialization environment, including universities' visions and mission statements.

7.3.9 Question 9: Awareness of legislation relating to IP within the commercialization environment

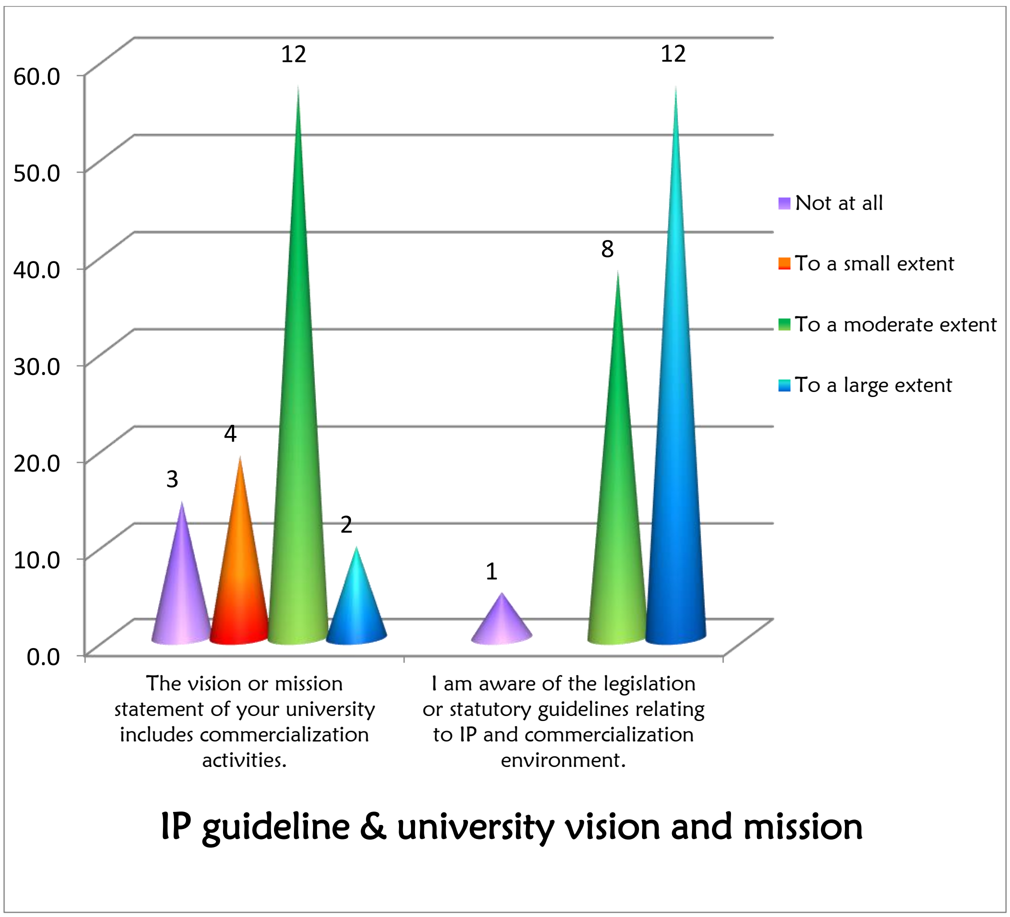

Figure 7.4: Statutory guidelines and university vision or mission statement.

Figure 7.4 reflects the respondent's awareness of the legislation or statutory guidelines relating to IP within the commercialization environment. Twenty of the respondents indicated that their awareness of statutory guidelines relating to the commercialization environment was of a moderate to large extent.

7.3.10 Question 10: Vision or mission statement relating to commercialization activities.

Only two university vision or mission statements included commercialization activities to any extent. A little over half of the respondents felt that their university's vision and mission relating to commercialization was evident to a moderate extent. Although there is very high degree of awareness relating to legislation or statutory guidelines, only two of the respondents were certain that their institution's vision or mission statements include commercialization. Four respondents indicated that their university vision and mission statement only included commercialization to a small extent, and three not at all. This indicates that commercialization activities are not high on the priority lists of a substantial number of universities.

7.3.11 Question 11: Percentage income retained by university

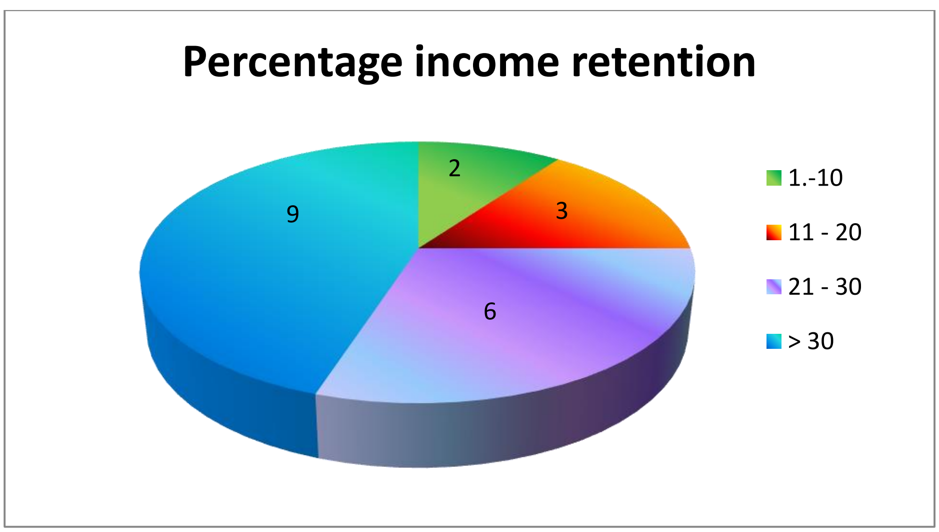

Figure 7.5: Income retained by university.

The distribution of income generated from commercialization impacts positively on innovators, although it is usually a long-term incentive mechanism. As indicated by Figure 7.5 above, one university retained between 1% and 10% of the income generated for commercialized innovation; three universities retained between 11% and 20% of the income generated; six retained between 21% and 30% of the income for the organization; and nine retained more than 30%. The high percentage that universities are retaining from income could result in low commercialization activity. According to Collier and Gray (2010: 67) incentive sharing is becoming as important as the salary packages to the recruitment and retention of staff. The percentage of income therefore becomes an important factor for universities to consider.

7.3.12 Question 12: Support of policy on income distribution generated from commercial activity.

Eight of the respondents did not totally support their university's policy regarding the distribution of income generated from commercial activities, while the remaining thirteen respondents were in support. According to Travis (2014: 1) the main benefit claimed for strong IPR protection was the fact that it has afforded innovators to appropriate a share of the benefits for their creative activities, which encouraged R&D resulting in innovation and higher long-term economic growth. It must therefore be considered whether the distribution of income to innovators acts as an incentive to their continued creativity.

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7.3.13 Question 13: Possible reason in response to previous question 12 in support of university policy regarding the distribution of income generated from commercial activity.

A significant minority (eight) of respondents felt that the income generated from commercial activity should be increased in favour of the innovator, and the university portion should be decreased. A greater monetary incentive to innovators is definitely a factor for consideration in encouraging future commercial activity. This is supported by Sibanda (2009: 1), who stated that motivations for IP creators at publicly financed institutions are regulated via the benefit sharing arrangements set by the Government.

7.3.14 Question 14: Is commercialization a high priority with senior university leadership.

Twelve respondents' perception was that IP was not considered a high priority with senior university leadership, while the remaining nine felt it was considered a priority. The IPR Act 51 of 2008 regulates that recipients of publicly-financed research are obliged to furnish proof of commercial activity. For the effective implementation of the IPR Act, an improved focus on the value of IP would result in enhanced IP management and commercialization practices within universities. The IPR Act has the ability to increase economic activities, which includes start-up companies, higher out-licensing revenues, job opportunities and increased R&D activities. This will ensure that IP emanating from public funds contributes to economic activity in the country. The university has a legal obligation to commercialize innovation created from publicly financed funding (South Africa, Intellectual Property Rights Act 51 2008). With the right to own IP emanating from R&D activities funded with public funds, recipients have an obligation to ensure that such IP is commercialized to the benefit of broader society.

This is supported by Collier and Gray (2010: 63), who stated that the significance given to an IP&TTO by university management performs a crucial element to success. They quote an IP&TTO director as follows: “I think we are very fortunate to have a succession of Vice-Chancellors who have been very supportive of the IP&TTO role, and the current Vice-Chancellor is no exception to that. That sets a tone around the University which would be very difficult to do our business without.” Buy-in from university management can provide a supportive culture likely to permeate throughout the university environment.

According to Collier (2008: 295) for a successful commercialization culture to exist, it must extend from the university Council to senior management, top executives, and the IP&TTO, through to researchers. Should this culture not exist throughout the university community, the prospect of success will be slim. The commitment of the university support structure must be representational and solid. It must allocate funds and investment in the IP&TTO by employing good quality staff. To retain staff the university ought to remunerate and motivate the staff appropriately. The university should create and sustain a milieu that identifies and inspires innovators. More importantly, it has to be prepared to commit to this for more than a few years for commercialization to become part of the culture of the university.

7.3.15 Question 15: Extent of obstacles to commercialisation activity

All respondents indicated that some obstacles were encountered in commercialization at their university. This implies that universities have put protocols in place that would make commercial ventures accountable. Almost half of the responses indicated moderate obstacles and a further six responses indicated large obstacles. The remaining four responses were to a small extent. Obstacles experienced at universities in terms of commercial activities may be directly linked to the low rate of university commercialization activity. Responses to the next question (number 16) attempts to capture the probable reason for such obstacles.

7.3.16 Question 16: Possible obstacles to commercialization.

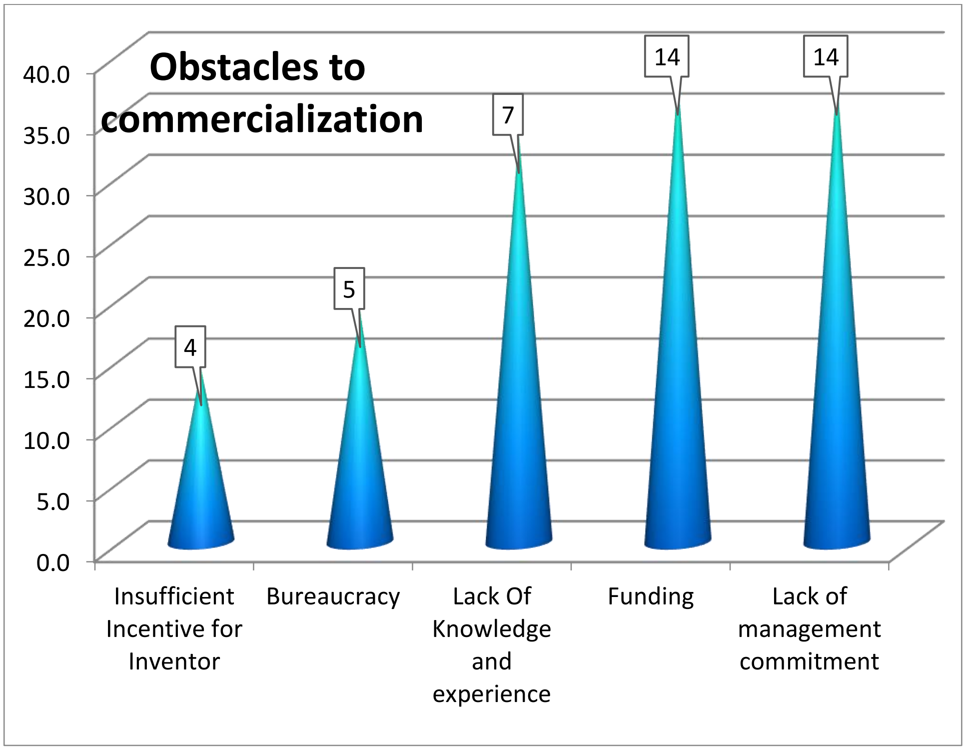

Figure 7.6: Obstacles to commercialization activity.

Figure 7.6 above indicates that the lack of management commitment and funding opportunities were the greatest obstacles to commercialization. This was followed by responses indicating the lack of knowledge and experience as a contributing factor. There is a common view that universities are hesitant to engage in commercialization, which may result from the fact that commercial skill and experience are generally uncommon in the university context. Other possible reasons provided by the respondents were bureaucracy within the universities and insufficient incentives for the innovator to engage in commercial activity.

The literature revealed (see section 2.7) that bureaucracy within the university structure is often a barrier to the commercialization of research. This is reinforced by Siegel *et al.* (2003: 41) and Sooreh *et al.* (2011: 188), who stated that bureaucracy and the inflexibility of administrative management systems in universities are considered major impediments to the success of commercialization. Conflicting demands between university researchers and industry managers arise, whilst the management at a university is tied up with its own internal bureaucracies. These bureaucracies discourage companies to collaborate with universities (Berman 2008: 168). Cervantes (2011: 3) reported that Tsinghua University of China offered added incentives to innovators for the commercialization of innovation, thus providing encouragement to engage in commercial activity. Aside from the lack of management commitment, IP improvement and commercialization strength cannot compensate for a country's weak national innovation system. Continual determinations in R&D, supplemented by proper skill and collaboration, are vital for commercial effort as noted. According to Brundenius, Lundvall and Sutz (2009: 17) and Zuñiga (2011: 32) issues such as the low technical capabilities of universities; inadequate cognizance on the benefits of IP; the absence of focus from industry partners in industrial expansion; and the total institutional weaknesses, have a direct impact on the low rate of commercialization. This is supported by Farsi, Modarresi and Zarea (2011: 4) who argued that three major contributing obstacles to commercialization are:

> *…internal factors such as disclosing of innovation, skilled staff employed at the IP&TTO and imposed legal costs (external) for protecting IPRs. Environmental factors are related to the economic and political conditions of a society and its sub structures and availability of services. Organizational factors regarding activities such as, motivation and organizational culture.*

Collier (2008: 54) believes that in instances where there is a lack of incentive that encourages innovators to engage in commercial activity, or when obstacles are large, universities will experience restricted success. Incentives include financial benefits to the innovator, while barriers include commercialization not being a factor in promotion:

> *…it appears that the propensity of innovators to disclose inventions, and thus increase the "supply" of technologies available for commercialisation, will be related to promotion and tenure policies and the university's royalty and equity distribution formula (Siegel et al. 2003: 44).*

7.3.17 Question 17: Policy, process and procedures amended.

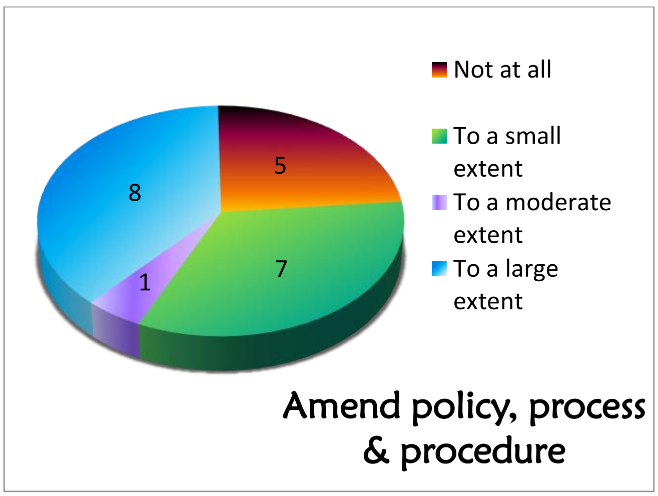

Figure 7.7: Should universities amend policy, process and procedure?

Responses to this question were fairly evenly balanced. Eight of the respondents agreed to a large extent that this change is required, with seven indicating to a small extent. Five respondents felt that their university did not require a change. As pointed out by Nelsen (2014: 538), university policy, process and procedures with regards to commercial activity require a structure and framework that include a clear policy on IP ownership; the role of researchers in collaboration with industry; and other ground rules to be set up prior to the commencement of a project. Working out such policies during the negotiation phase can lead to confusion and bureaucratic lethargy thereby slowing down the process, which impacts negatively on the university's reputation of being unable to conclude agreements timeously. Tanha (2011: 15) added that the lack of adequate venture capital for investment in new technologies, and the lack of solid rules and regulations for protecting IPR's, are seen as potential obstacles to university commercialization.

7.3.18 Question 18: Reasons to amend policy, process and procedures.

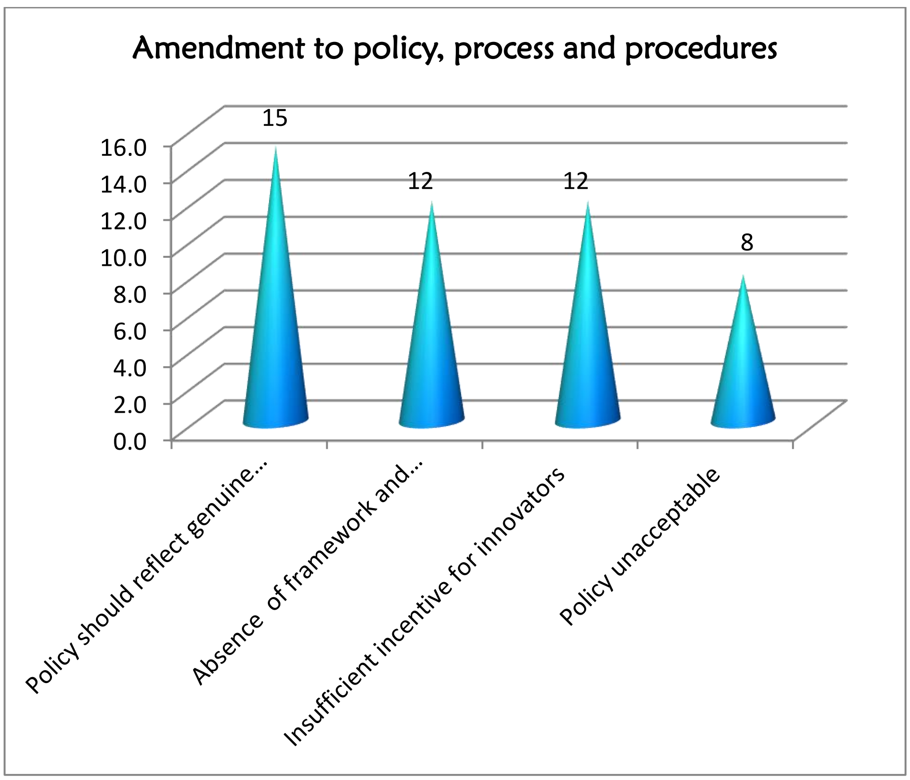

Figure 7.8: Amend policy, process and procedures.

Fifteen respondents commented that the university policy does not reflect genuine commitment from university management. Half of the respondents agreed that the absence of a framework and structure enabling commercialization impacts negatively on such activity. Studies by Elmuti, Minnis and Abebe (2005: 1011), Chiesa and Piccaluga (2010: 201) and Mahboudi and Ananthan (2010: 2) also found that the lack of a framework and structure enabling long-term strategies hinders commercialization. Twelve respondents indicated insufficient incentives for innovators. This is complemented by Collier and Gray (2010: 88) however, who stated the possibility of universities modifying the policy in terms of promotion criteria to allow for a focus on commercialization outcomes. This could encourage researchers to think more earnestly regarding the prospects and benefits that can arise from commercial activity. Cervantes (2011: 3) reported that Tsinghua University in China offers its young researchers awards for innovations that are commercialized, which provides encouragement to the innovators. Eight respondents found the university policy to be ‘unacceptable’, which translates into inefficient management of intellectual property (Siegel *et al*. 2003: 43).

As reported by Collier and Gray (2010: 88) support for commercialization from university management is one of the most crucial ingredients for innovation to prosper. The development of a university culture inclusive of innovation and entrepreneurship is a complex challenge, but one that requires urgent attention.

7.3.19 Question 19: University support for commercialization of research.

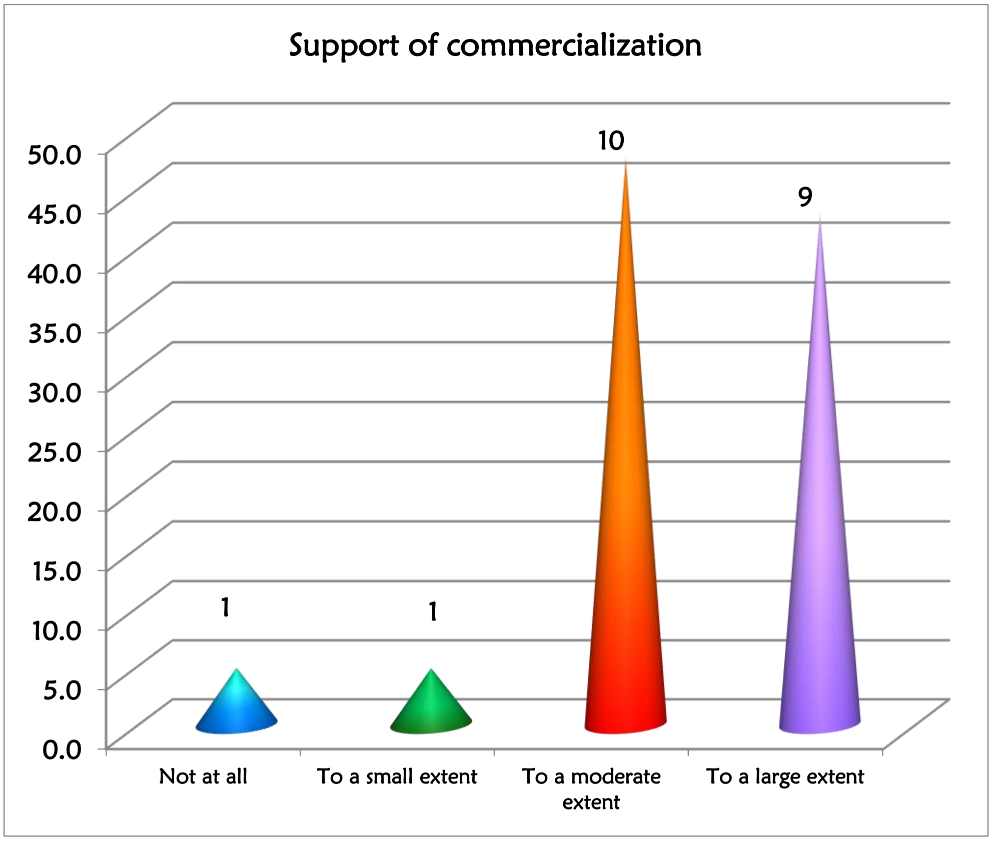

Figure 7.9: Could the university do more to support commercialization.

Nineteen respondents agreed that their universities could do more to support commercialization. Some of the ways in which the university could do more to support commercialization is discussed in section 7.3.20.

Commercialization is measured as a key indicator of academic power as it institutes direct, quantifiable market approval for outputs of academic research (Markman, Siegel and Wright 2008: 1411), and for this reason alone universities ought to offer greater support for commercialization. This response is further supported by Litan *et al*. (2010: 12) who stated that:

"…given the importance of researchers to innovation and commercialization, a university culture that is accepting of entrepreneurial activities is best built from the ground up by researchers who promote and connect other colleagues both inside and outside of academe".

According to Rasmussen (2008: 506) (see section 3.6) Canadian universities have entrepreneurial programmes designed to induce structural reforms within the university sector in order to improve the institutional capabilities in facilitating commercialization projects. In support of commercialization and aside from establishing specialized structures such as IP&TTO's, a few universities globally have set up science parks and incubators (Wright *et al.* 2007: 17 and Siegel *et al.* 2003: 38), which include supportive internal rules and procedures (Thursby 2009: 113).

7.3.20 Question 20: Suggestions in support of commercialization

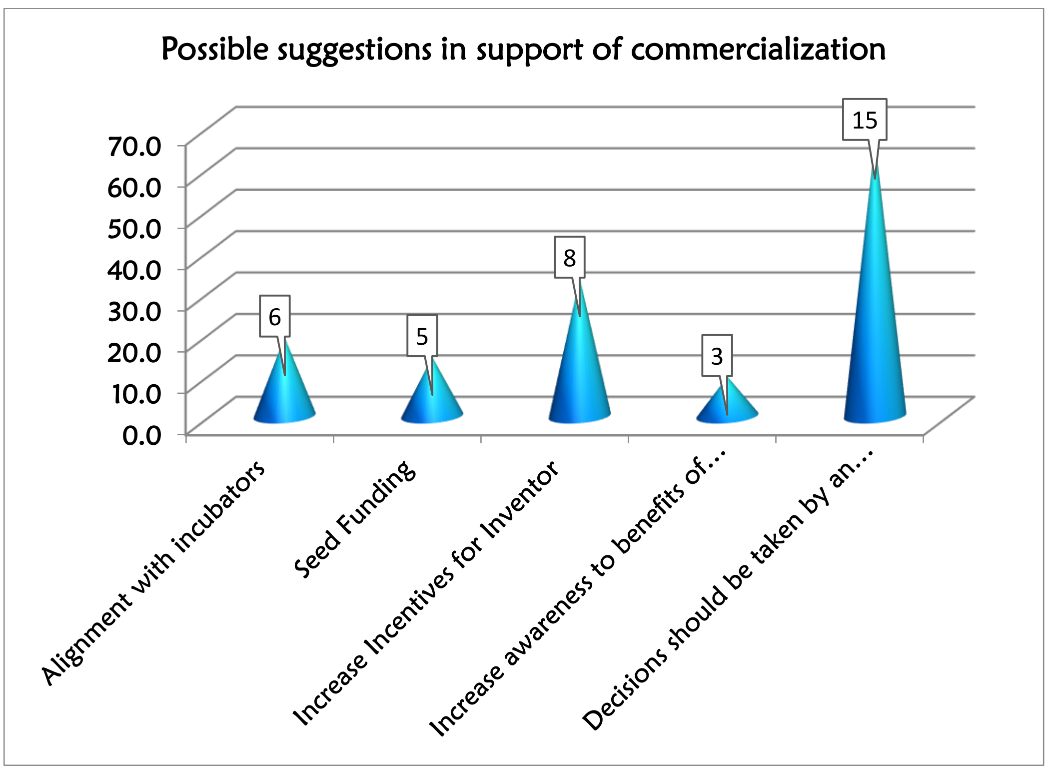

Figure 7.10: Possible suggestions in support of commercialization.

Possible suggestions were made in ways the university could support commercialization. A large number recommended that the decision to commercialize should be taken by an advisory committee. Slightly more than half of the respondents suggested that universities should utilize incubators and seed funding opportunities. Other respondents were of the opinion that universities ought to increase awareness on the benefits of commercialization.

Canterbury University in New Zealand has initiated new practices to assess the commercial potential of innovation for commercialization. At most universities innovations are identified and the decision to proceed with IRP protection and commercialization is taken at the university IP&TTO, although Canterbury University has two committees which are used to assess and advance commercialization. First there is an internal screening committee which is presented with an innovation by the business development manager. If the decision is taken to proceed, the screening committee has a business case prepared in conjunction with the innovator and then decides whether the idea should proceed to the commercialization committee. The commercialization committee is comprised of members external to the university, plus co-opted expertise, in order to assess the recommendations of the screening committee and to make the final decision to allow (or not to allow) the innovation to proceed to commercialization (Collier and Gray 2010: 24). The broad involvement of a cross-section of stakeholders in decision-making on research priorities contributes towards accountable and adequate decisions.

Universities may well consider the increase of innovators' incentives to reassure greater involvement in commercial activity. According to Collier (2008: 130) and as discussed in section 3.3.1; 3.4.2; 3.6.2 the significance of distribution of income from commercialization with the innovators is for early stage innovation to succeed from innovators input. The continual support of the innovator is therefore essential, therefore a reasonable distribution of profits is appropriate to promote commercialization.

Suggestions from this study will be in keeping with the study by Litan, Mitchell and Reedy (2007: 13) who confirmed that an ideal university structure would support all aspects of the process, from the concept stage all the way through to commercialization. They further suggested that universities ought to identity methods to reduce transaction costs in rapidly conveying scientific discoveries into the marketplace. These costs include expenses related to the identification, protection, and modification of innovation and commercialization, as well as administrative expenses and opportunity costs for the time that would be required from researchers. To reduce these costs, universities should adopt something such as a "value chain" model (Phan and Siegel 2006: 7) that encourages universities to disaggregate their functions and assign them to specialists, while leveraging outside organizations and other partners in the process.

To repeat an earlier emphasis, expert commercial management skill, infrastructure and experience are required to assist with the commercialization of IP at universities. Many innovators do not have the relevant expertise and thus require the assistance of people who possess the skill and expertise. A focus on the essential skill provided within the university structure would ensure efficient commercialization practice.

University IP&TTO's provide numerous facilities aimed at cultivating commercial activity such as provision for the patent application process; licensing agreements; identifying collaborative partners and funding source; and training and support in the creation of university-based spin-offs (Guimon 2013: 7). Although the university may provide IP reform and commercialization efforts, a university cannot compensate for a country's weak national innovation system. Sustained efforts in R&D to develop the appropriate technological capabilities and linkages are required before relevant returns appear in the form of commercially successful spin-off companies or patent licensing. Thus in developing countries, the results of IP reform tend to be disappointing (Brundenius, Lundvall, and Sutz 2009; Zuñiga 2011). The reasons for this are the low technological capacities of universities (in terms of both human capital and infrastructure); the limited awareness of the benefits of IP among researchers and industry; the lack of interest among firms in technological development; and overall institutional weaknesses.

7.3.21 Question 21: Researchers allowed time for commercial activity.

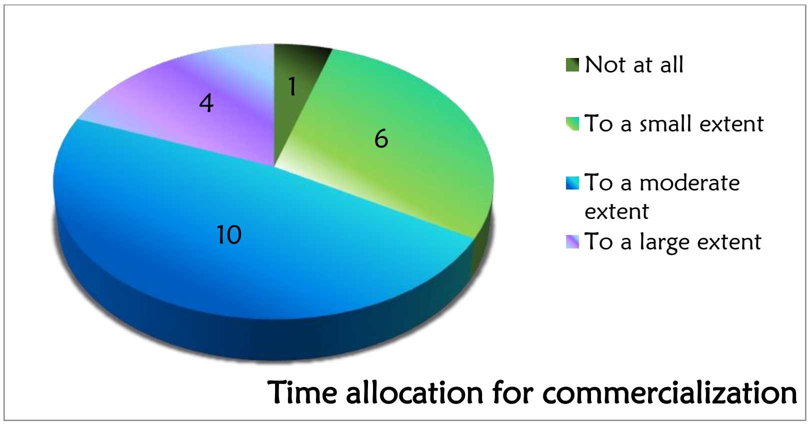

Figure 7.11: Time afforded for commercial activity.

A large number of the respondents (almost half) indicated that academics should be afforded time for commercial activity to a moderate extent. The literature reveals that commercial activity can be a time consuming activity. The success of commercialization often depends on the researcher's involvement because of the complementary tacit knowledge, without which the project could prove unsuccessful, as indicated by the United *Nations Economic Commission for Europe* (2011:31). In a study of university IP&TTO's in the USA, it was measured that 71% of the innovations could not be fruitfully commercialized without the innovators participation (Thursby 2009: 114).

The question that is often disputed is whether academic entrepreneurship is part of the nature and purpose of universities. A further debate entails as to whether a university's purpose is education for education's sake and whether research conducted for knowledge is for knowledge's sake. In Bok's (2003: 162) opinion, "those who decry the rise of commercialization at universities, are misguided", and he is supported by Baxter (2011: 191) who states that it is short-sighted to believe that an academic researcher is employed for basic research and teaching only. Time and effort should also be invested towards commercialization activity because of the potential positive impact.

Collier and Gray (2010: 24) contended that commercialization is an extra load on an academic researcher over and above the teaching, research and community service obligations. Incentives for the added workload are provided to encourage engagement in commercial activity, although these are not consistent amongst all the universities. Benefits to academics come in several forms, the most usual being relief from teaching obligations, monetary reward, enhanced reputation, and promotion. One of the usual benefits academic researchers receive is relief from their teaching load while they participate in industry-related activities such as commercialization (Collier 2008: 24).

Embryonic university discoveries often require further technical and market development, for which the inventor's effort is required. This is consistent with results of USA universities which reflect that three-quarters of the licensed innovations are normally at proof-of-concept or laboratory-scale prototype, which necessitates technical development requiring the innovator's involvement (Dechenaux, Thursby and Thursby 2011: 98). Braunerhjelm and Svensson's (2010: 122) study of patents granted in Sweden indicated that when a patent is licensed to an established firm the profits are higher with the inventor's continued involvement. It seems that the inventor's participation is important for further adaptation of the innovation to reduce uncertainty.

7.3.22 Question 22: IP registration and commercialization results considered for academic promotion.

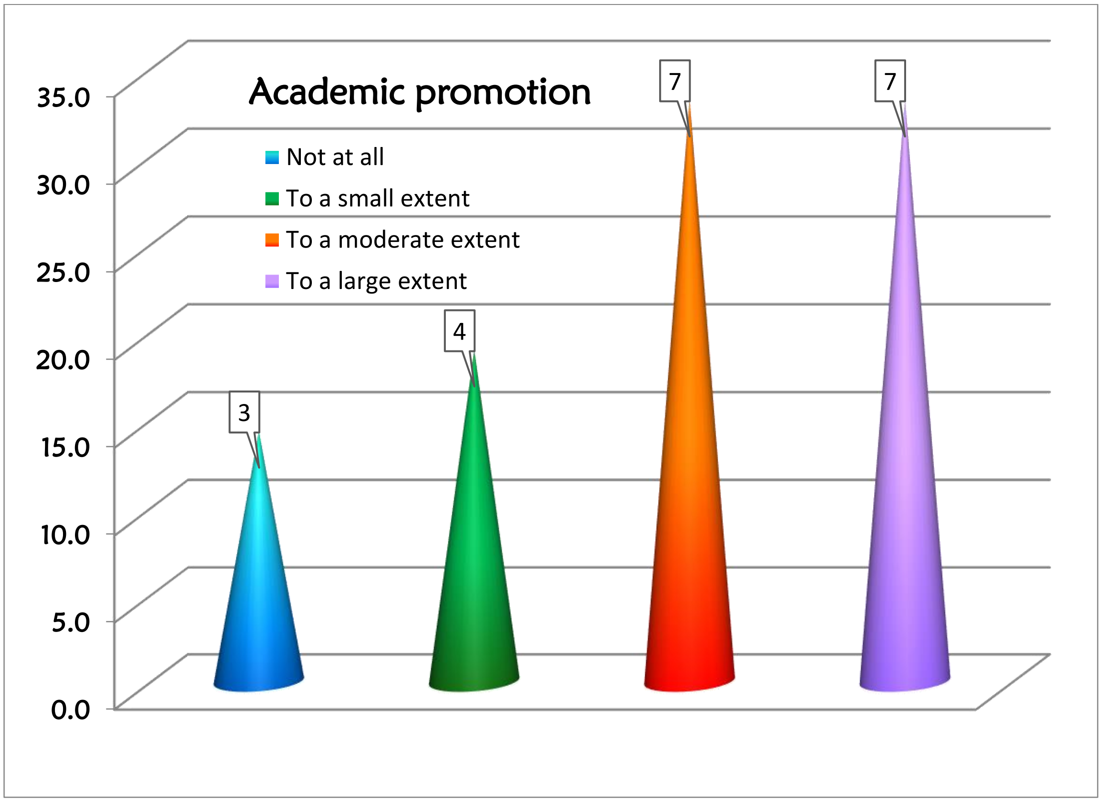

Figure 7.12: IP activity considered for academic promotion.

Two-thirds of the respondents believed that IP registration and commercialization should be included in the promotion criteria.

According to Eesley and Miller (2012: 83) academic promotions at Stanford University are based on the excellence of scholarship, service and teaching. Stanford University does not consider commercial activity or patent ownership as a contribution towards the decision for promotion, and this is typical of many universities. That said, researchers involved in commercialization tend to be prominent in their field of research. Meyer (2006: 1158) maintained that academic researchers proficient with commercial activity are also often strongly involved in publishing. Franzoni and Lissoni (2009: 6) and Landry, Amara, and Ouimet *et al.* (2007: 568) concurred that academics engaging in knowledge diffusion also have high levels of research output and superior performance in their field of expertise. The acknowledgment of an academic for IP activity would not be substituting recognition and valuation of publications or awards attained, but would rather serve as an additional reflection. Neither Stanford University, MIT nor Wisconsin University embrace the word 'patent' in their elevation and tenure guidelines. According to Emery (2014: 21):

> *"…the University of Wisconsin's policy states: "granting of tenure is based on evidence of a record of professional creativity, such as research or other accomplishments appropriate to the discipline - other accomplishments" can mean a plethora of things, and each tenure review committee will evaluate each activity on a case-by-case basis".*

Traditional promotion criteria and entrepreneurial activities can therefore co-exist. Additionally, robust focus on commercialization and entrepreneurship increases basic research, as academics attempt to link their work to economic requirements (Martin 2012: 546). As highlighted by Baxter (2011: 32), commercialization revenues are generally invested back into basic research. University management should therefore acknowledge the benefits of commercial activity by increasing their focus on academic entrepreneurship. Sanberg (2014: 1) stated that authors have generally taken the position that universities should expand their criteria to treat patents, licensing and commercialization activity as an important consideration for merit, tenure, and career advancement, along with publishing, teaching, and service.

SECTION D: Management of commercialization activities

The focus of this section is on the management of commercial activities. Specifically, it will examine whether the decision to pursue the commercialization of innovations should be a collective decision involving various stakeholders within and outside the university environment. Other specific elements include whether the present structure and arrangements within universities promote commercialization activities, and if there a strong relationship between the IP&TTO and the university research office to support commercialization.

7.3.23 Questions 23: Relationship between IP&TTO and the university's research office.

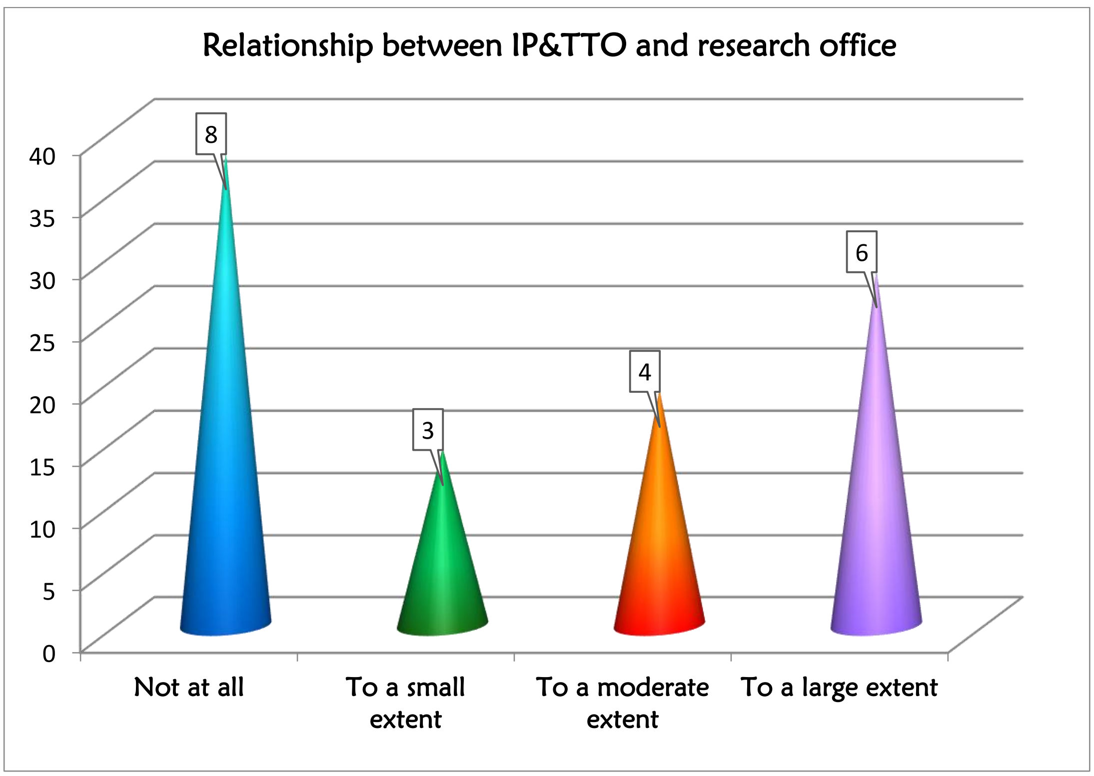

Figure 7.13: Relationship between IP&TTO and research office.

Figure 7.13 demonstrates the strength of the relationship between the IP&TTO and the research office in support of commercialization. Eight respondents indicated that this relationship did not exist at all, with only six respondents of the view that this relationship did exist to a large extent.

The literature (see section 4.6) reveals that the relationship between the IP&TTO and the research sector can be stronger within a joint collaborate effort. According to Collier and Gray (2010: 85) intermediaries in the research office specialize in linking innovators with industry, which is likely to create commercial innovations from research output. It is therefore crucial that there is a strong relationship between the research office and the IP&TTO.

7.3.24 Question 24: Do present structures and arrangement promote commercialization activity?

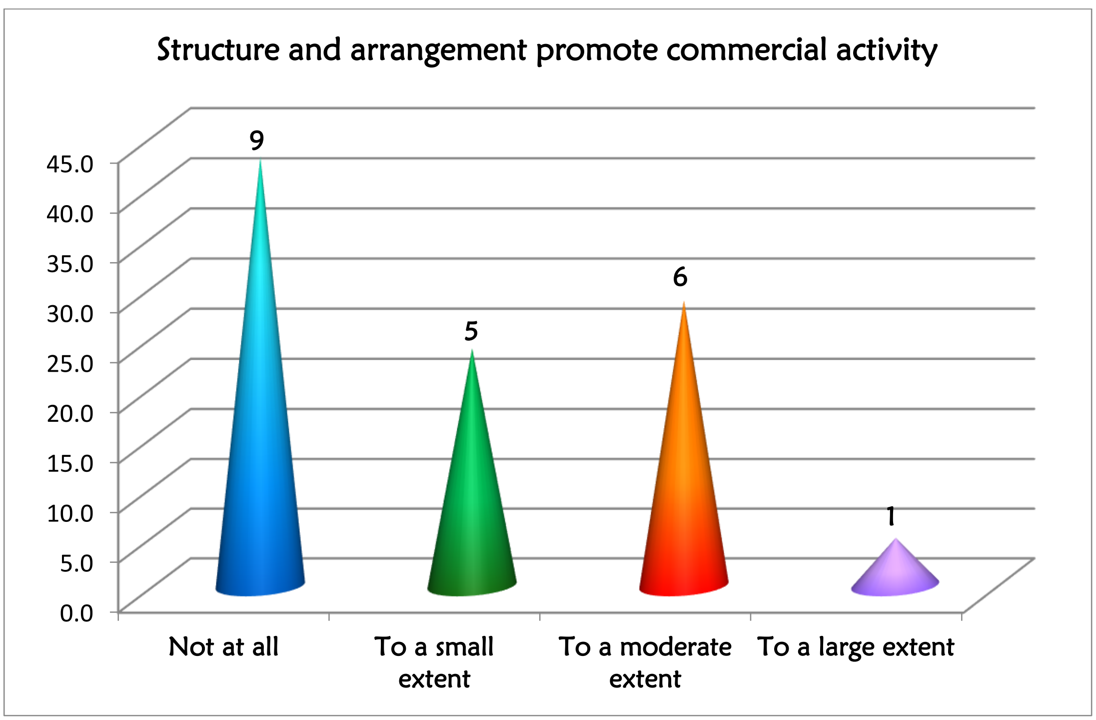

Figure 7.14: Represents structure and arrangement.

Question 24 enquired as to whether the present structure and arrangement within the university promotes commercialization activities. Nine respondents felt that their university's current structure and arrangement did not support commercialization activities at all, while five respondents felt this occurred only to a small extent.

According to Litan, Mitchell and Reedy (2007: 1) university structures should support all aspects of this process, from invention to innovation as well as commercialization. As discussed in the literature review (see section 1.7.3) the internal and external support structures are critical to enable commercialization activities at the university. These structures include the IP&TTO; business incubators; joint ventures; spin-off/start-up companies; and Science Parks. Science Parks can act as a business incubator aimed to increase entrepreneurial activities in terms of spin-off and joint ventures. Seigel, Wright and Lockett (2007: 644) suggested that the rise of academic entrepreneurship required a re-examination of a university's organizational structure and practices for the success of commercial activity. As discussed in section 5.2, commitment from university management is required for increased promotion of commercialization activities.

7.3.25 Question 25: Stakeholders inclusion in decision-making

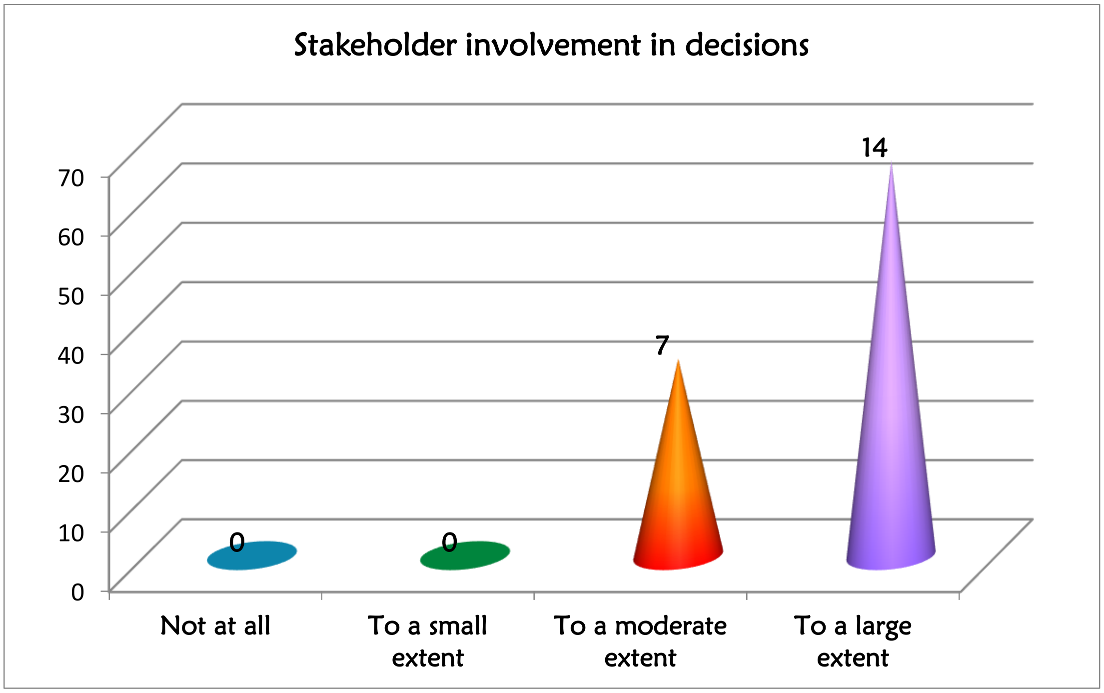

Figure 7.15: Stakeholder involvement

Figure 7.15 above reflects views that the decision to pursue the commercialization of innovation ought to be a collective decision involving multiple stakeholders within and external to the university. Slightly more than two-thirds of the respondents agreed to a large extent that this should include all possible stakeholders in the decision-making process, although the remaining one-third were of the view to a moderate extent.

There is a risk of bias on decision making that would need to be managed. Litan, Mitchell and Reedy (2008: 51) indicated that one of the largest disadvantages of the traditional IP&TTO model is *'who'* decides which technologies will actually make it to the market. At Canterbury University, as noted, all new disclosures are assessed by two different committees, namely, a screening committee and a commercialization committee (Collier and Gray 2010: 24). Mulder (2008) and Oluput (2009: 110) argued that due attention to all invention disclosures and evaluation ought to be based not only on commercial potential but also on social benefits where innovation is applicable.

7.3.26 Question 26: Rank types of IP

This question established the different types of IP with which South African universities are engaged (most common disclosure) namely, new-to-the-world products; new products and services that allow expansion into new customer groups; new products and services for existing customers; minor changes to existing products and services; and cost reductions for existing products and services.

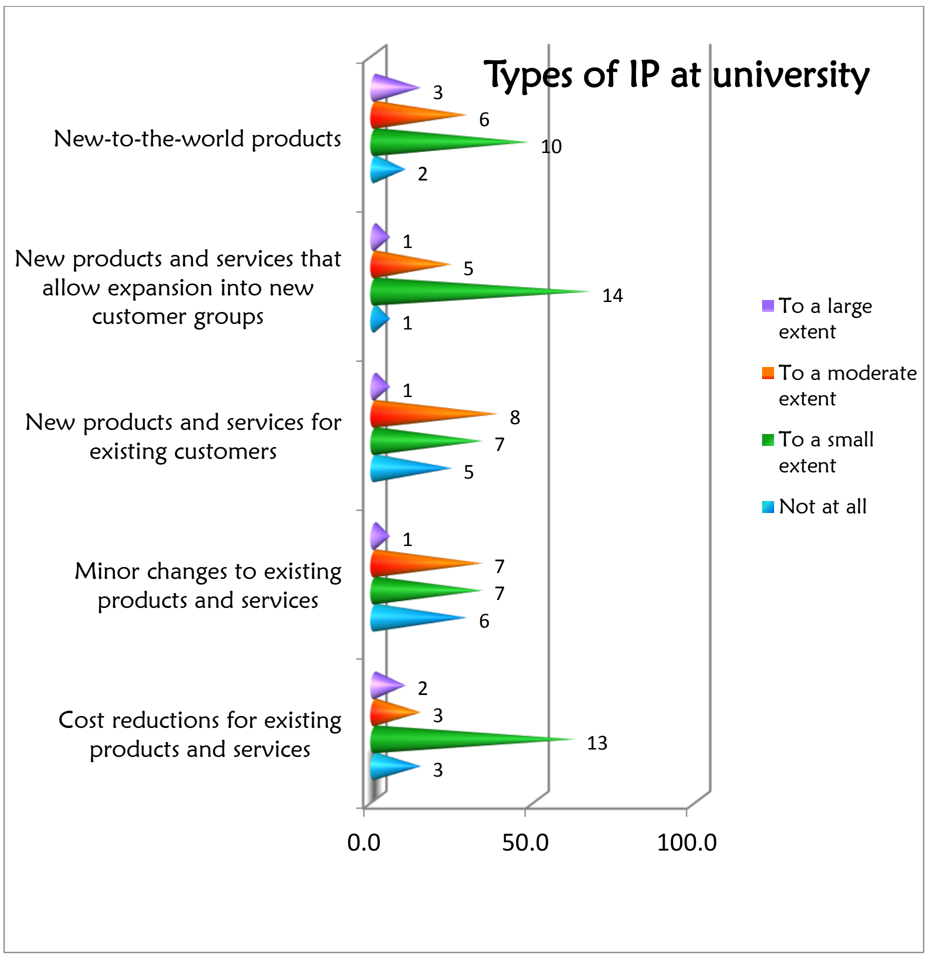

Figure 7.16: Types of IP at universities

Nine universities indicated that new-to-the-world products were the most common on their IP portfolio to a moderate or large extent, while six universities indicated that new products and services that allow expansion into new customer groups was most common for them. New products and services for existing customers was found to be most common at a total of nine universities. Eight universities found that minor changes to existing products and services was a large part of their IP portfolio. Cost reduction for existing products and services was common in only five universities. For three of these (new-to-the-world products, new products and services for existing customers and minor changes to existing products and services), universities were roughly balanced in terms of the number which focused on these to a large or moderate extent on the one hand, and to a small extent on the other. In two cases (new products and services that allow expansion into new customer groups and cost reduction for existing products and services), most universities dealt with these only to a small extent. Innovation and technological progress can raise productivity through the improvements of existing goods, thereby reducing the costs of production. Few universities with research outputs which are not at the technological frontier are likely to be engaged in productivity through follow-on innovation and adaptation (Boyes 2014: 2). Sander (2012: 1) provided a reason for the type of research universities are most commonly involved in and stated that:

> "*…it's important to understand that over 70% of US university research is categorized as 'basic' (research for the sake of knowledge) vs. applied development (research for the sake of meeting a specific market need through development of a product or service). As a comparison, typically less than 10% of corporate research is categorized as basic. Basic research provides the foundation for fundamental technology breakthroughs for next generation corporate products, establishing a key role for US universities in the overall advancement of technology today and in the future"*.

7.3.27 Question 27: Business models

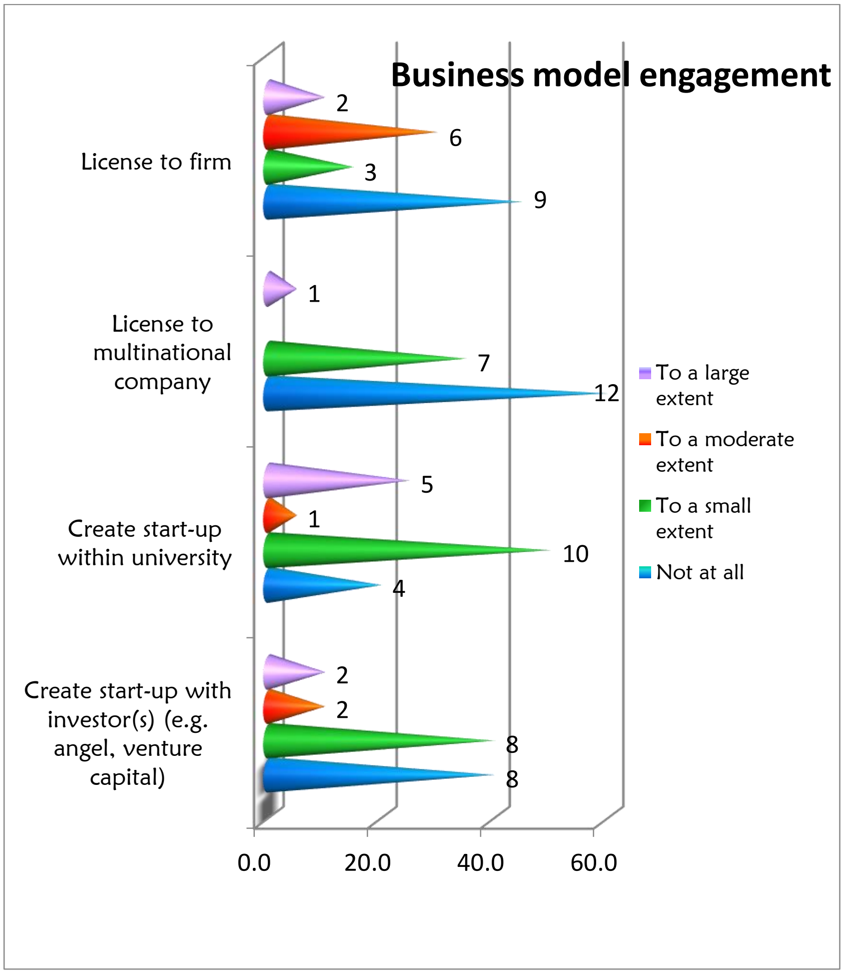

Figure 7.17: Indication of university business models

As reflected in Figure 7.17 above, eight universities indicated that licensing to industry is undertaken from a moderate to a large extent. Evidence of licensing to a multinational company was only undertaken by one university for the period 2008-2013. Six universities indicated the creation of start-up companies from a moderate to large extent, and ten universities indicated start-ups within the university to a small extent.

The creation of start-up companies within the university environment has become a common recent occurrence. Sander (2012: 6) stated that between 500 and 600 new universities spin-off companies are being formed annually, and these have had a high track record of survival and success. For example, the AUTM (2012) U.S. universities licensing activity survey reported $36.8 billion in net product sales from licensed technologies in the fiscal year 2012, from which university tech transfer offices themselves received $2.6 billion in total licensing income. A study of Cambridge University spin-outs discovered that university spin-outs have a larger progress prospective than industry spin-outs (Wicksteed 2000a: 76). American universities typically transfer their technologies via both licensing and new ventures creation. Some ventures are academic spin-offs, however others are created by independent financiers who sign a licensing agreement with the university. Technology licensing and start-up companies perform diverse but balancing roles that benefit specific areas of the university commercialization process. Only four South African universities indicated that the creation of start-up companies with investors such venture capitalists or angel investors was done to a moderate or large extent, while eight indicated that this was done only to a small extent.

Often innovators are at a crossroads on whether to license a technology to an existing industry partner or to create a start-up company for commercialization. In some European countries Government and IP&TTO managers prefer start-up companies as opposed to licensing strategies (Cervantes 2011: 13), which aligns with Sander's (2012: 6) comment on the USA trend. The probable reason stems from increased growth in Government subsidized venture funds that are targeted to stimulate new company establishment. The key question remains, however: Which is the best method for conveying innovation to the marketplace? To Ismail *et al.* (2008: 183) the key is the innovation itself. Innovation with a greater range of possible utility can be commercialized via a start-up company, although others may be licensed to established companies with the ability to grow the innovation further and incorporate it into its R&D and business strategy (Cervantes 2011: 4). This is reinforced by Collier (2008: 296), who added that licensing an innovation to an existing company active in that field is considered the best mechanism.

It is noted that varied strategies may occasionally not be compatible. Should the formation of a spin-off company be selected it is vital to retain the innovation as confidential, as disclosure may allow other companies with large resources to develop and produce similar products. If no spin-off company established, it could be realistic to ensure the innovation is dispersed in appropriate circles so that it spreads to potential licensees. Of course if confidential information is transferred, then a non-disclosure agreement should be signed prior to sending the information. A tactical study recognizing the potential of the innovation and the probable drawbacks may possibly accelerate the innovation into commercialization.

According to Thursby and Thursby (2004 cited in Ismail *et al.* 2008: 172) and Shane (2004 cited in Ismail *et al.* 2008: 172), early-stage technologies have the tendency of being associated with uncertainty and risk, and therefore require funding to progress to the commercially viable stage. Normally, innovations with radical, tacit knowledge are general purpose with strong IP protection that ends in spin-off formations. Innovations at advanced stages of growth have adequate customer values, with codified knowledge, specific purpose with weak IP protection, and have a tendency to be commercialized through licensing to established corporations (Ismail *et al*. 2008: 173). Both early-stage and later-stage innovation tend to be licensed to well-established enterprises, however, depending on the commercial viability of the technology (Ismail *et al*. 2008: 174). Lockett *et al.* (2003 cited in Ismail *et al.* 2008: 181) indicated that a survey of 57 UK universities, revealed that universities new to commercialization opt for licensing patents to established companies because of the absence of clear strategies and resources at the university. Other IP&TTO's may select to license to well established companies to generate instant cash and royalties, rather than establishing a new spin-off company which is considered risky and requires additional expenditure, skill and expertise (Baxter 2011: 37). There is an inherent bias towards licensing to established companies, however, due in part to risk aversion and the need for immediate generation of revenue.

SECTION E – Status of patents

This focus of this sections to ascertain the status of patents at the universities. The extent of commercialization activity and the number of successfully commercialized patents.

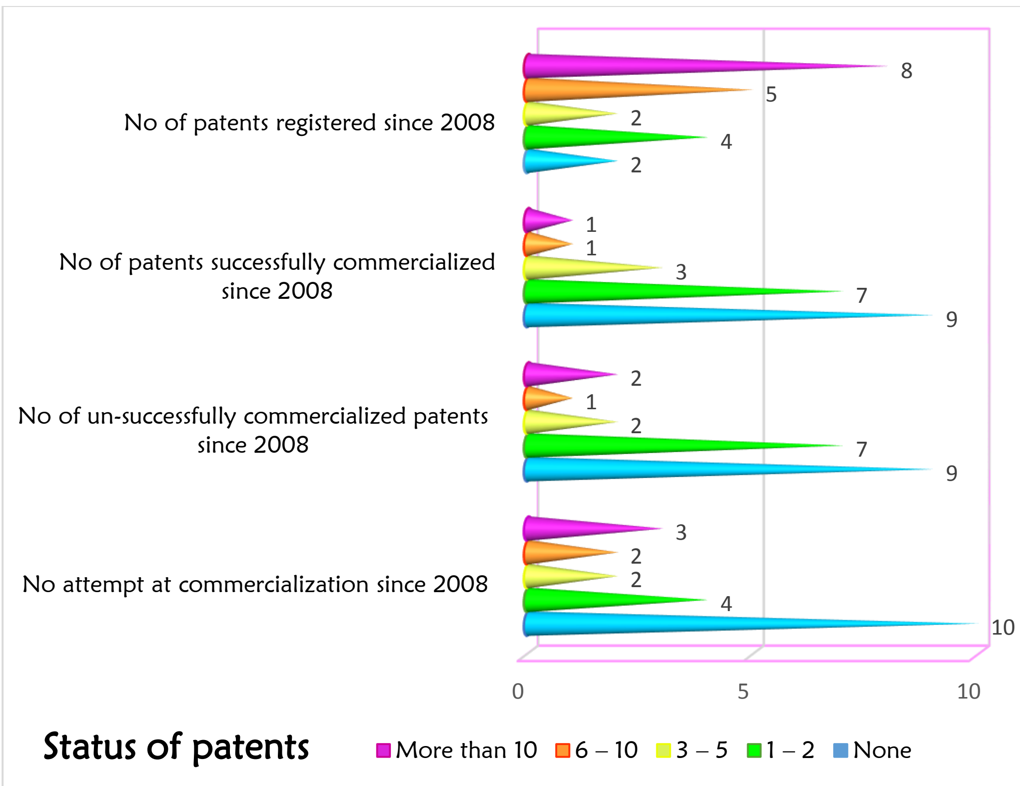

Figure 7.18: Reflects the responses to question 28 – 31 which cover the status of university patents and commercialization.

7.3.28 Question 28: Number of patents registered from 2008 and 2013

For the period 2008-2013, eight universities reported to have registered more than ten patents and five universities registered between six and ten patents. Two universities had not registered any patents during that period, while four universities had reported to have only registered one or two patents for that specific period.

Kruss (2006: 24) attested that there has been emphasis on universities registering patents from publicly funded research, as the perception that exists is that South African universities have a poor record of registered patents. This is supported by Boschoff and Mouton (2003 cited in Alessandrini, Klose and Pepper 2013: 17), who confirmed that the bulk of South African patents are individually owned, while universities do not feature on the list of top ten South African patenting organisations. This is further re-enforced by Sibanda (2009: 1013), who reported on the low rate of patenting by South African universities at both local and international levels. In contrast, the University of Southampton and Warwick University in the UK are reported to identify the market size, potential value of an innovation, the key players in the field and their potential customers before filing for patents. Only inventions that have commercial value and that need protection are patented. As discussed in section 5.2, full due diligence is required before committing significant resources to patenting and licensing out for further development and spin-out companies where appropriate. Low patent counts in South Africa could be partly attributable to due diligence.

An important issue concerns the factors which determine the different levels of success in commercialisation between South African universities, as identified particularly by the second component of Figure 7.18. The following potentially important factors were identified:

- The length of time a university's IP&TTO has been in existence (see section 7.3.4) i.e. longer experience could be expected to enhance commercialization.

- Number of staff employed in the IP&TTO office (see section 7.3.5) i.e. more staff could be expected to enhance commercialization.

- Percentage of income retained by the university (see section 7.3.11) i.e. retaining a small proportion could be expected to enhance commercialization.

- The perceived priority given to commercialisation by senior management (see section 7.3.14) i.e. higher priority could be expected to enhance commercialization.

For the first three variables - for which ratio data were collected – it was possible to calculate Pearson correlation coefficients which provide a measure of the degree of association between two variables. They provide evidence (or not) concerning causality but do not prove it. The respective correlation coefficients and their associated p values were 0.427 ($p=0.065$), 0.163 ($p=0.471$) and 0.046 ($p=0.926$). Only the first (length of time of existence of the IP&TTO office) came close to being significant at the traditional five per cent level and suggests that long-established offices are more successful in commercialisation. Of course, a long existence itself may be associated with other factors which promote commercialisation success. The perceived priority accorded to commercialisation by senior management is measured in nominal form. Chi square tests (chi square = 3.316, $p=0.400$) indicate that there is no relationship between this factor and commercialisation success. Part of the reason for this inconclusive set of results is the small number of universities concerned.

7.3.29 Question 29: Number of patents successfully commercialized since 2008

Only one university reported having commercialized over ten innovations, while one other university indicated between six and ten innovations had been successfully commercialized. Three universities have commercialized between three and five innovations, while the remaining seven universities are reported to have commercialized either one or two innovations. Nine universities have indicated that none of their innovations had been commercialized. This obviously denotes a very poor level of performance; even the universities which have commercialized a patent since 2008 are averaging only around one such commercialization per annum.

With regard to the increasing international call for modification in the measures of innovation and commercialization endeavours in particular, there seems to be an absence of agreement among South African universities in relation to the methods and techniques that ought to be utilized to gauge achievement. The existing units of measure, specifically patents and commercialization numbers and profits, are not considered as a sufficient measure of success of commercialization undertakings. According to Alessandrini, Klose and Pepper (2013: 16), the commercialization of innovations can be estimated on the basis of wider social benefits, in particular: (1) job creation; (2) accessible technology based products and services; (3) reduction in poverty and mortality; (4) other measures of social impact on communities; and (5) the long-term financial benefits to the country as a whole.

7.3.30 Question 30: Number of unsuccessful attempts at commercialization since 2008

Two universities reported that more than ten project had unsuccessful attempts at commercialization; one university reported that between six and ten projects they had experienced unsuccessful attempts at commercialization; and a further two universities had between three and five innovations projects that were reported as not commercialized. A large number of seven universities experienced unsuccessful attempts at commercialization. The remaining nine universities reported to have had no un-successfully attempts at commercialization since 2008. However, it must be noted that as reflected in section 7.3.28 two of the nine universities had not registered any patents since 2008.

7.3.31 Question 31: Number of patents with no attempt of commercialization since 2008.

Three universities in possession of more than ten patented innovations had made no attempts at commercialization. As reflected in Figure 7.18, ten universities had no patents to which no commercialization attempts were made, however two (see section 7.3.28) of those universities had no registered patents since 2008. Two universities are reflected in Figure 7.18 as having between 6-10 patents to which no commercialization attempt was undertaken. The remaining six universities were in possession of between 1 – 5 patents to which no commercialization attempts were made.

The literature (see section 5.6.1) reveals that patents do impact on the decision to commercialize innovations. It must therefore be understood that all innovations which have attributes of novelty, usefulness and non-obviousness are potentially patentable, which raises the probability of an attempt to commercialize. As Webster and Jensen (2011: 24) found, however, many unpatented innovations are commercialized. Thus, it can be concluded that patents are neither essential nor an adequate formula for commercialization. There is also an indication that university patents may deter or slow down industrial innovation (Fabrizo 2007: 19). Breschi *et al*. (2008: 93) attested, however, that academic innovators publish more papers of superior value than those of researchers without patents, and increase their productivity after patenting. As emphasized by Scott (2012: 14), patents are seen as catalysts to the collaboration between university-industry commercialization. Furthermore, Rhodes (2012: 13) found that low university patent counts can be attributed to high patent protection costs. Dwindling budgets at universities have a direct impact on patent counts.

Boyes (2014: 2) indicated that as innovations are typically intangible, the measurement thereof is not straightforward. Since innovations are difficult to measure, the measure of commercialization diffusion becomes imperfect. While innovation commercialization is considered to be an important source of productivity growth, a number of alternative measures of innovation have been employed, though all have their advantages and disadvantages. It can be argued that the success of a university's IP&TTO should not be measured by patent counts or the number of successful or unsuccessful commercial attempts. Rather, it should be measured by the value of licenses and the number of new spin-off companies created. This way, universities may be able to maximize the economic and social returns from innovation.

According to Wits Enterprise (2012) the university has managed patenting as an academic exercise. They have focused on patenting but not on the transfer of patents into outcomes. In the future, patenting decisions would need to be based on all available information in order to patent only where it will create value. Universities' financial investment in IP registration becomes a futile exercise if patents do not have commercial value. Universities ought to be focused on IP with a high potential of success in the marketplace.

F - Early Stage Financing and Venture Capital

This section enquires on the university's participation in obtaining pre-seed funding and venture capital for commercialization. Access to external funds and extent of funding opportunity with industry and government partners to facilitate the raising of funds for commercialization.

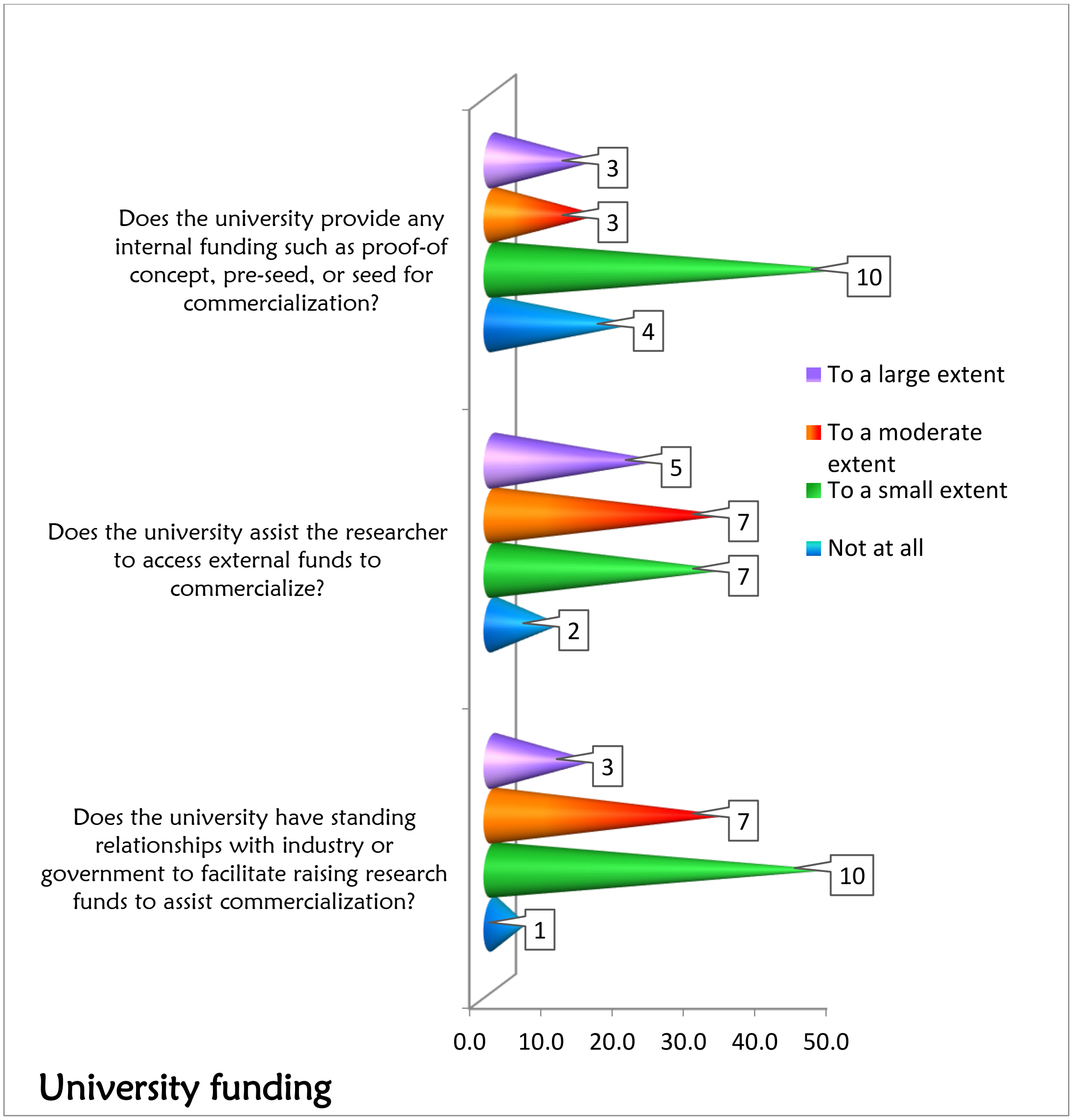

Figure 7.19: Responses to question 32, 33 and 34 which illustrates funding opportunities.

7.3.32 Question 32: Internal proof-of-concept, pre-seed or seed funding for commercialization

Only three universities are reported to provide funds for commercialization to a large extent, while a further three universities to a moderate extent. This represents less than a third of universities that provide funds to assist with commercialization. Fourteen universities were reported as providing funds for commercial activity only to a small extent and, in some cases, not at all.

Commercialization success at Australian universities maybe be attributed to the Government implementing a number of programmes and actions designed to promote commercialization (Allen 2003:7). These include providing an environment to inspire funding schemes such as Management & Investment Companies, Pooled Development Funds, Venture Capital Limited Partnerships Program and providing funds to certain levels and stages of development. Further, the Australian Government is known to fund the development of a commercialization training scheme intended to train researchers in commercialization (Department of Education Science and Technology 2007: 6).

7.3.33 Question 33: Access to external funds

Five universities are reported to assist researchers in accessing external funds for commercialization to a large extent, while seven respondents indicated that their universities assisted to a moderate extent. The remaining seven universities only assisted to a small extent, while two universities did not assist at all. It can be concluded that through the lack of an internal provision of funds universities are accessing 'crowdfunding' for commercialization, ie. the practice of funding projects or ventures by raising small amounts of money from a large number of people, typically via the Internet.

Crowdsourcing acts as a financial incubator for early-stage research, university fundraising, and getting ideas to market (Macdonald 2013: 1).

7.3.34 Question 34: Relationship with industry and government partners for funding opportunity

Almost half of the universities reported having, to a small extent, some standing relationship with industry and Government to assist with the commercialization of innovation. Ten others indicated to a moderate extent and the remaining one indicated to not having any such relationship. The literature (see section 4.6) reveals that since 2008 industry has expressed concern on the full-cost model of the IP Act. It is understood that the Act has induced industry reluctance to provide the full-cost of research. The Act may also possibly have further blocked relationships with universities by the restrictions imposed through non-disclosure agreements.

The responses received regarding access to external funds for the commercialization of university innovation is not in keeping with universities in the USA. Stanford University does not collect, track or maintain information about funding as part of its general entrepreneurship programmes. Some universities invest directly in start-up companies created by their innovators. Stanford University does not have this kind of institutional incubator, although some investments are made by companies which have licensed university innovations. Data provided by Stanford Innovation Survey during 2011 indicated that $88 billion in funds were estimated to have been raised by 11,565 companies founded by Stanford alumni who graduated after 1990. Companies created by graduates over the past two decades estimated $3.5 million on average was raised in external funding. Almost 9% (972 firms) received venture capital funding; more than 10% (1,104 firms) received funding from angel investors; almost 4% had foundation funding; and 5% received other types of funding.

Hall (2004: 23) revealed that industry was of the opinion that, “we own the IP developed for us under sponsored research. This view is often not shared by potential university partners.” and that, “many universities want to publish results prior to IP protection, and sometimes will not grant exclusivity”. These types of remarks by industry indicates probable reasons for industry reluctance to fund university research since the enactment of the IPR Act 51 of 2008.

SECTION G – University-industrial linkages

This section enquires on the extent to which universities market innovation for commercialization and the use of intermediaries as facilitators. University engagement in joint research venture or encourage research of commercial potential.

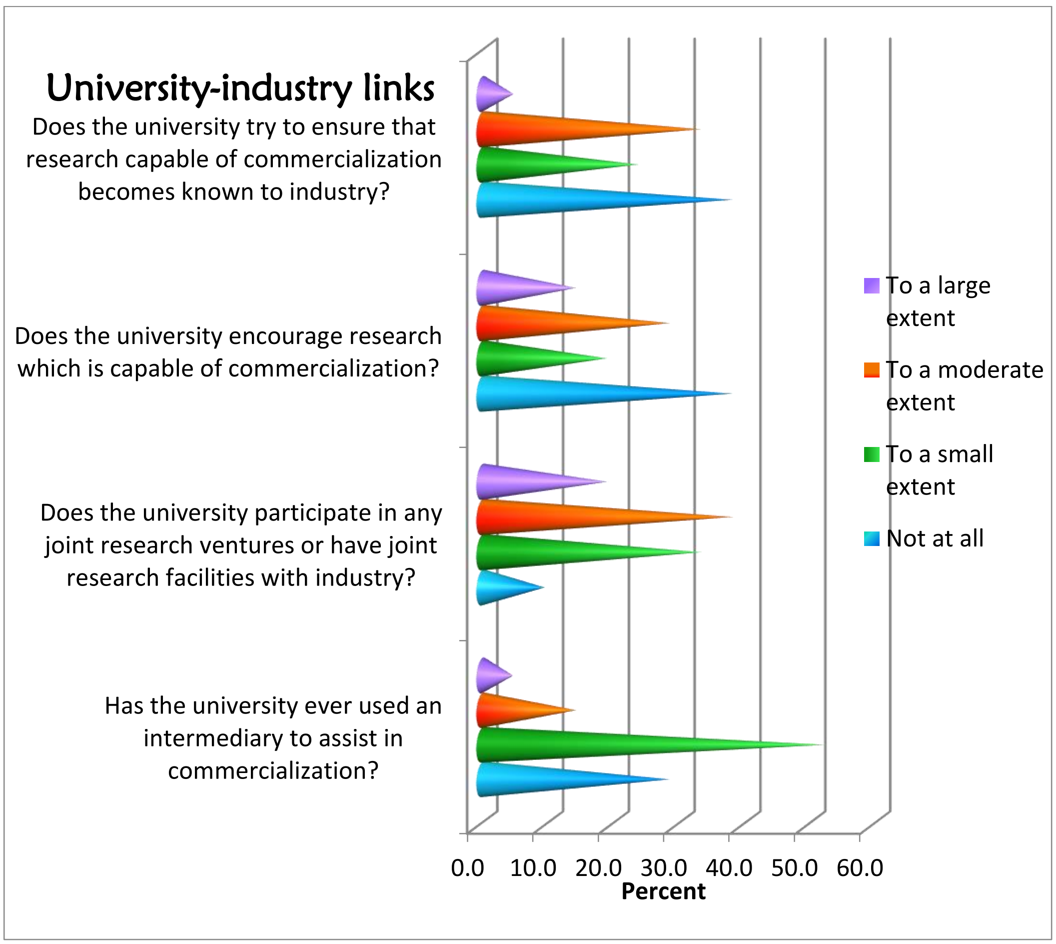

Figure 7.20: University-industry linkage

7.3.35 Question 35: Marketing of university innovation to industry

Only one university reported making big efforts to create awareness of innovations capable of commercialization into industry. Seven universities indicated that such innovations were made known to industry to a moderate extent, while a further five universities only created the awareness to a small extent.

Many innovators are of the opinion that they do not possess the commercial knowledge and expertise to engage with industry with regard to commercializing their research. As a result, concepts and inventions go unnoticed because innovators fail to recognize the commercial value of their innovation and are hesitant to involve the IP&TTO unless they identify benefits to their innovation. Universities should therefore find ways of ensuring that research capable of being commercialized becomes known to industry.

Collier (2008: 296) posited that associations with industry are vital to the success of an IP&TTO. For commercial success effective links and relationships with industry are vital, although it seems this is often the chief weakness in a university's struggle to promote innovation (Lambert 2003: 108). To reinforce this, Canadian universities have developed a successful model for working with industry, involving the use of 'showcases' where industry is invited to presentations relating to innovations (Collier 2008: 299).

7.3.36 Question 36: University encouragement of research capable of commercialization.

Three universities reported encouraging research capable of commercialization to a large extent, while six universities encouraged research to a moderate extent. A further five universities performed this only to a small extent and the remaining seven universities indicated that this was not at all encouraged.

Many countries' IP legislation dictates vigorous commercial participation of publicly funded research in the context of reduced Government funding of universities which acts to motivate commercialization. Baxter (2011: 41) suggested that universities can offer a climate conducive for entrepreneurship by providing training and opportunities for increasing skills and marketplace awareness to guide research direction on industry requirements and societal needs. This is supported by Kamara (2012: 2), who highlighted that societal cognizance is necessary for innovative activity to take place. Mintzberg (1994 cited in Kamariah *et al.* 2012: 683) asserted that innovators require to ascertain prospects further than prevailing capabilities to sustain their endurance. Environmental conditions are also found to motivate individuals within the university to inspire an entrepreneurial culture.

7.3.37 Question 37: Joint research venture with industry

Four universities reported participating in joint research ventures with industry to a large extent, with fifteen doing so from a small to moderate extent. Universities and industry are not natural partners: their cultures and their missions are different. This results in a communication gap between academics and industry partners which can impede the smooth exchange of knowledge and research output. To commercialize innovation a university can license IP to an existing company or create a start-up company. For universities to establish start-up companies, large amounts of venture capital for research and development laboratories are required. These necessary basics are not within the usual range of a university's competency. The importance of joint research collaboration is therefore necessary for university innovation.

Understanding how an innovation can successfully be taken to the marketplace is not necessarily instinctive to academia. This may be taught in engineering and business curricula, although it is best learned through practice and experience. Entrepreneurs flourish in an environment that shares concepts and inventive stimulus vital to creating new innovations. Universities need to recognize the importance of providing an environment that assists new entrepreneurs to understand the commercialization process and how an idea becomes a product. The literature (see section 3.7) reveals the UK university strategy of success in building networks between stakeholders from academia and industry. This helps to create shared trust, improve a culture of common goals and objectives, and provides a mutual language which in turn permits the interchange and creation of knowledge.

7.3.38 Question 38: Intermediary assistance with commercialization

Six of the universities have never used an intermediary to assist with commercialization, while eleven reported using an intermediary only to a small extent. Only one university indicated to have used intermediaries to a large extent, and three to a moderate extent.

These results may suggest that universities are not adequately utilizing the assistance of intermediaries to engage with commercial activity. It points to the relevance of intermediaries linking universities to industry in effort to increase the potential of converting research into commercial products.

Baxter (2011: 81) argued that intermediaries assist in speeding up the process of commercialization by offering expert advice and assistance, and link the entrepreneur with potential customers. They detect prerequisites and where assistance can be obtained, as well as connecting new ventures with commercialization partners. Intermediaries can provide business mentoring to new ventures and entrepreneurs. Stern (2011: 1) affirmed that intermediaries have the ability to present an external perspective with unbiased evaluation and critical thinking. Stern (2011: 1) further stated that commercialization activities are shaped by key intermediaries, such as entrepreneurial academics and IP&TTO personnel. These actors are situated at the intersection of the academic and commercial arenas and thus fulfil the role of intermediaries. Weckowska (2010: 6) declared that it is assumed that the commercialization of university innovation often involves sharing knowledge across communities of practice that is across cognitive, cultural and institutional gaps.

SECTION H - General Views

The next three questions are open-ended and relate to general views on various areas. These include the strengths and weaknesses of the university's commercialization policy and practice; factors that would inspire universities and researchers to participate more vigorously in commercialization; and the role Government could to play in commercialization.

7.3.39 Question 39: Strengths and weaknesses in policy and practice

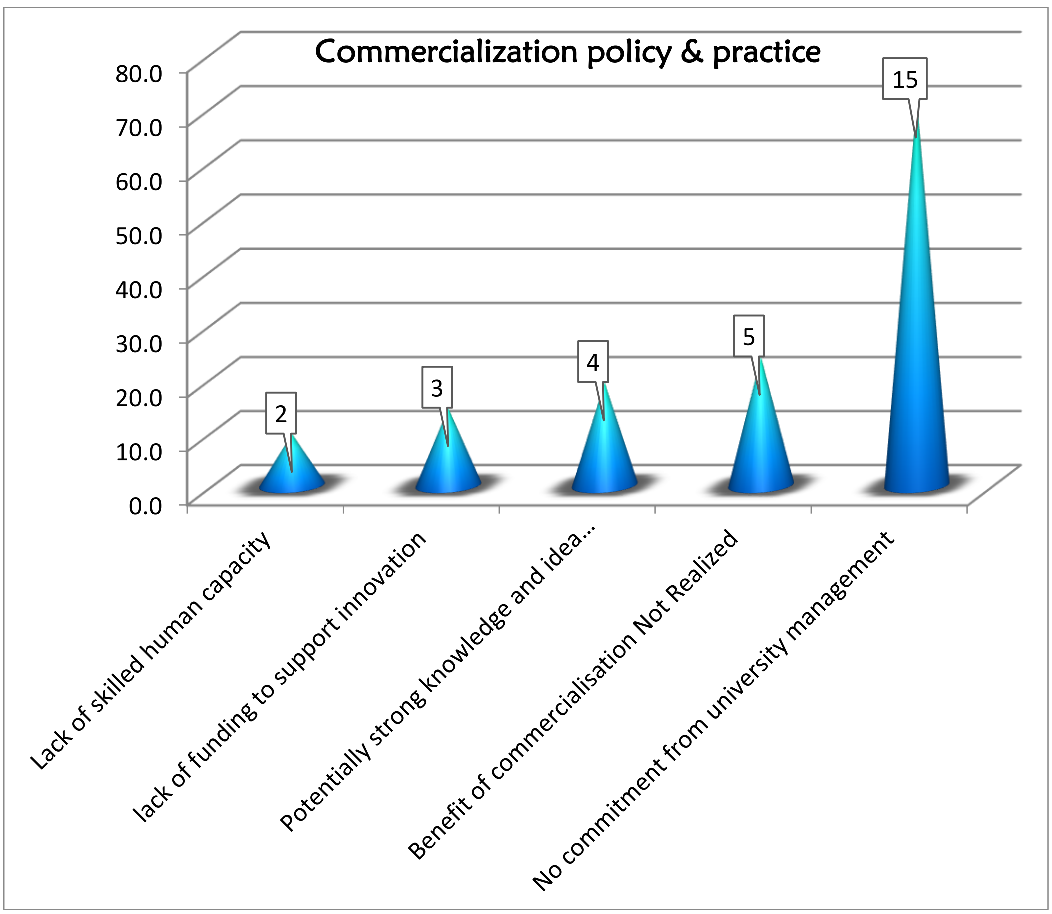

Figure 7.21: Strengths and weakness in commercialization policy and practice.

Fifteen respondents indicated that there was no commitment from university management with regard to commercialization practice. This is a key finding of this research. University commitment to IP commercialization is regulated by the IPR Act 51 of 2008. Collier and Gray's (2010: 63) study found that the significance given to commercialization by senior management performs a vital ingredient to success. Their study quoted an IP&TTO director:

> *"I think we are very fortunate to have a succession of Vice-Chancellors who have been very supportive of IP&TTO and our role, and the current Vice-Chancellor is no exception to that. That sets a tone around the University which would be very difficult to do our business without."*

Support for commercialization through mechanisms such as operational structures within which commercialization functions, as well as efforts to recognize, capture, protect, disseminate and exploit innovation created from publicly funded research seems to be lacking at universities, particularly in South Africa. The lack of commitment from senior management has implications for understanding the benefit of commercialization to an individual and the university collectively. Innovators need to be aware of successes and prestige associated with commercial success. It is easy for researchers to be discouraged by the lengthy and time consuming patent registration process, which can be changed by an institutional environment of encouragement.

7.3.40 Question 40: What would inspire university researchers to participate more vigorously in commercialization of research?

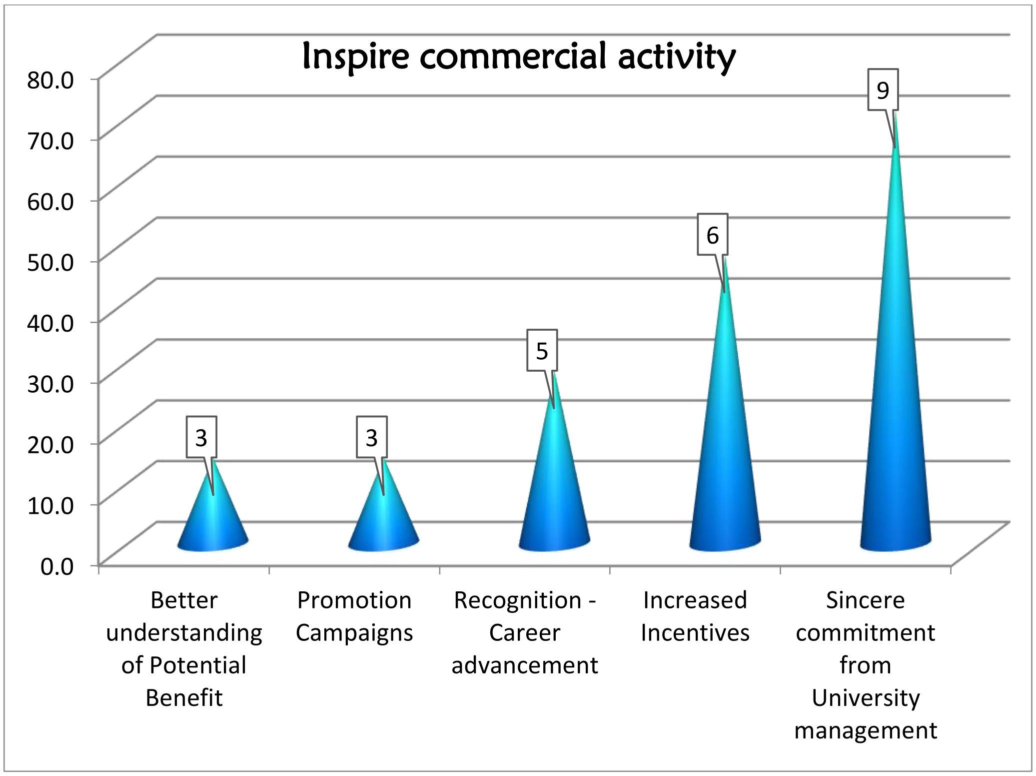

Figure 7.22: Reasons to participate in commercial activity.

Nine respondents agreed that sincere commitment from university management would be a positive step toward encouraging increased commercialization activity. Should a positive entrepreneurial environment exist with university management, researchers would appreciated and understand their commitment. This is in keeping with Beckett (2012: 3) findings that "respondents who became entrepreneurs in the past decade, 55 percent reported to choosing to study at Stanford because of its entrepreneurial environment. Stanford's entrepreneurial culture provides great flexibility in launching start-ups". Mulder (2008) has argued that IP&TTO's in South Africa were faced with common commercialization challenges as discussed in section 5.2. The most significant challenge highlighted by IP&TTO managers was getting the university leaders to embrace technology transfer and commercialization activity.

Six respondents indicated that the financial reward for the innovators be increased to provide incentives for creativity. One of the key challenges for IP&TTO's is to find the means to support researchers to become adept in IP management. According to the Wits Enterprise (2012: 4) perspective, there is an onus on innovators to work for the public good, and the Act guarantees that the innovator will share in the financial and non-financial benefits, even though the university owns the IP. Collier (2008: 294) explained that, all Australian universities afford two precise motivations for innovators to participate in commercialisation: they allow up to 20% of paid time for academics to undertake personal commercial activities, and a share in commercialisation profits.

Commitment from university management includes motivation for commercial effort and financial support. Management at most universities expect the IP&TTO to be self-financing. Given the nature of difficulty to commercialization and barriers to funding opportunities, commercial activity requires significant investment of time and funds in order to be lucrative.

7.3.41 Question 41: Role government should play in research commercialization process

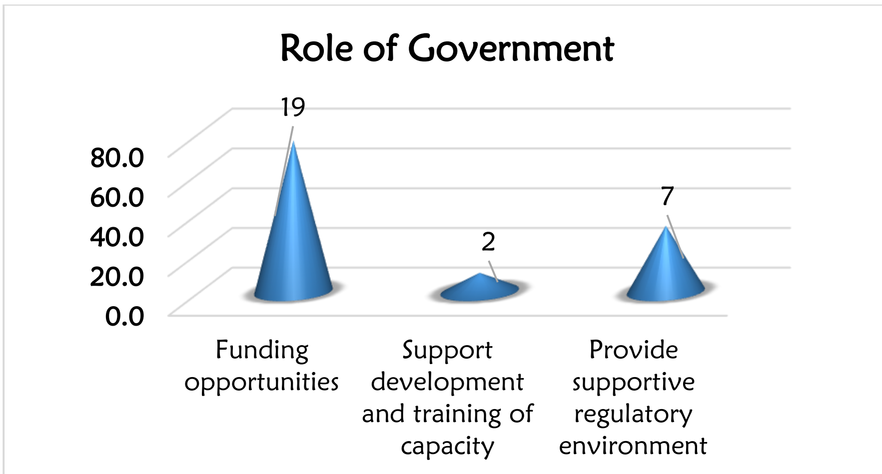

Figure 7.23: Role of government in support of commercialization

Nineteen of the respondents agreed that the Government should provide more funding opportunities for individual researchers, and a third of the respondents were of the view that the Government ought to increase their supportive and regulatory environment. Nairo (2011: 8) maintained that the chief barrier to the commercialization of university innovations is the lack of experienced technology transfer professionals. The skills of such professionals are in short supply, due to Government-employed rules and pay-scales that restrict universities from providing competitive earnings to such professionals. There is a need for the Government to invest in the specialized training of IP&TTO professionals at universities.

As previously discussed (see section 5.8), Government support programmes have been implemented by most countries to control the proper management and commercialization of innovations that stem from publicly funded research. There have been Government programmes that support university commercialization for three to five years. Thereafter, according to Nelsen (2007: 540), there is an expectation that the IP&TTO would become self-supporting and would be surrounded by a flourishing cluster of companies, which is unrealistic. This does not happen that quickly. Building a regional economy based on entrepreneurialism is a slow, gradual process Nelsen (2007: 540). Baxter (2011: 44) maintained that "large corporations and universities with an inclusive world-wide outlook saw the most important role for government regarding IP matters as making certain a consistent and dependable business-friendly economic, regulatory and legal context". Bozeman (2005: 632) added that, "government's role on commercialization should chiefly be to remove barriers to the free market, through appropriate IP policies, free trade agreements, neutral impact taxation and limited regulation of enterprise".

7.4 Summary

The main points from the survey of IP&TTO managers revealed: 1) the lack of senior management commitment to commercialization; 2) the decision to commercialize innovations to be taken by an expert advisory committee; 3) insufficient incentive for innovators to engage in commercial activity; 4) insufficient funding opportunity for commercialization; and 5) the lack of local industry receptors to induce engagement.

University inadequacies range from the absence of an emphasis on commercialization, to a low to non-existent entrepreneurial culture. Deficiencies in commercialization knowledge among researchers was emphasized as another barrier. The results revealed that not all barriers are common between universities and some barriers may be more excessive than others. It is likely that the impediments vary between universities based on an individual's overall knowledge of the commercialization process.

Chapter 8

RESULTS AND ANALYSIS OF INTERVIEWS

8.1 Introduction

An interview schedule was the second tool used to collect data. The interviews sought further explanation of the data which emerged from the questionnaires completed by IP&TTO managers. The composition of the interview population was made up by innovators affiliated to one of the 23 universities. As discussed in section 6.3, the innovators were creators of innovation to which patents are registered against the name of their affiliated university. Information was sought from innovators in possession of registered IP, but not as yet commercialized. The convenience sampling method was used to select innovators at an innovation exhibition arranged by the Department of Science and Technology in an effort to promote the commercialization of innovation from publicly funded research. A total of 21 university innovators were invited to participate; seventeen positive responses were received, however only thirteen interviews were carried out with success.

8.2 INTERVIEW RESULTS

8.2.1. Question 1: Type of university

This question was formulated to distinguish between the number of innovators employed at traditional academic universities and the number of innovators employed at a University of Technology (UoT).

It is evident from the responses received that seven of the interviewees were from the traditional academic university, whilst the remaining six innovators represented the University of Technology (UoT).

8.2.2 Question 2: Faculty of respondent

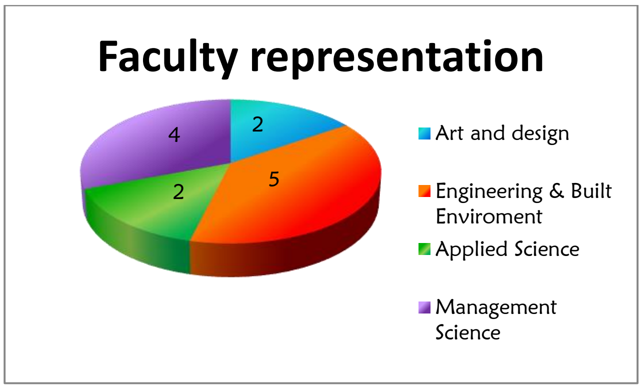

Figure 8.1: Represents the faculty of the respondent

Two of the interviewees belonged to the Faculty of Art and Design; five to the Faculty of Engineering and the Built Environment; two to the Faculty of Applied Sciences; and the remaining four to the Faculty of Management Sciences.

8.2.3 Question 3: Awareness of ownership provisions

Ten of the thirteen innovators were aware of the ownership provisions, while only three were not aware of the ownership provisions entitlement. With such knowledge of ownership provisions, innovators will be better positioned during negotiations for commercial opportunities and astute to incentives and royalty distributions stemming from commercialization.

8.2.4 Question 4: Agreement with ownership provision of the IPR Act.

All of the innovators who were interviewed disagreed with the provision of the IPR Act, to varying levels of disagreement. The aspects of disagreement included: IP ownership registration in the name of the affiliated university; royal distribution; and, commercialization strategy. This contrasts with the responses of the IP&TTO managers (see section 7.3.6), all but one of whom were in total agreement with the ownership provision of the IPR Act.

8.2.5 Question 5: Is commercialization a priority at the university?

Twelve of the innovators felt that their university did not practice commercialization as a priority at the university. It must be noted that a high number of both innovators and IP&TTO managers (section 7.3.14) were of the opinion that commercial activity at their university was not considered a high priority.

8.2.6 Question 6: Entrepreneurial culture

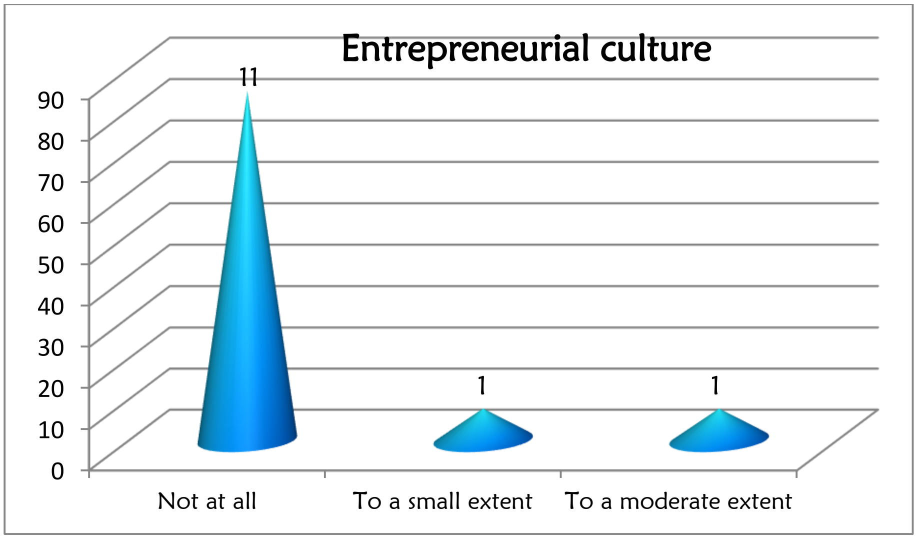

Figure 8.2: Entrepreneurial culture at the university.

It is clearly evident that the majority of the respondents felt that an entrepreneurial culture did not exist at their university.

At USA universities, where entrepreneurship has been vigorously taught for decades, innovators who created new products, production processes or business models, and entrepreneurs, were more likely than other alumni to have participated in entrepreneurship courses and programmes (Eesley and Miller 2012: 46). The literature reveals (see section 2.8.1) that approximately 25% of technical innovators took an entrepreneurship course at Stanford University. The terminology "science-directed commercialization" referred to by Gulbrandsen and Slipersaeter (2007: 34) stresses the prominence of innovators *as the engine* of the commercialization process. The success of commercialization, it seems, depends largely on the innovator of the IP.

8.2.7 Question 7: Income distribution

The question of whether innovators supported their university's policy regarding the distribution of income generated from commercial activity received an overwhelming response of dis-agreement. This response may be a contributory factor to innovators' reluctance to engage in commercial activity. The literature (see section 4.2 and 5.2) also reveals that attribution provides incentives for innovators to continue with creative activity. Innovators reluctance was largely attributed to their dissatisfaction with the income distribution policy (see section 5.9.2); this is followed up in question 8.

8.2.8 Question 8: Reasons for dissatisfaction with income distribution

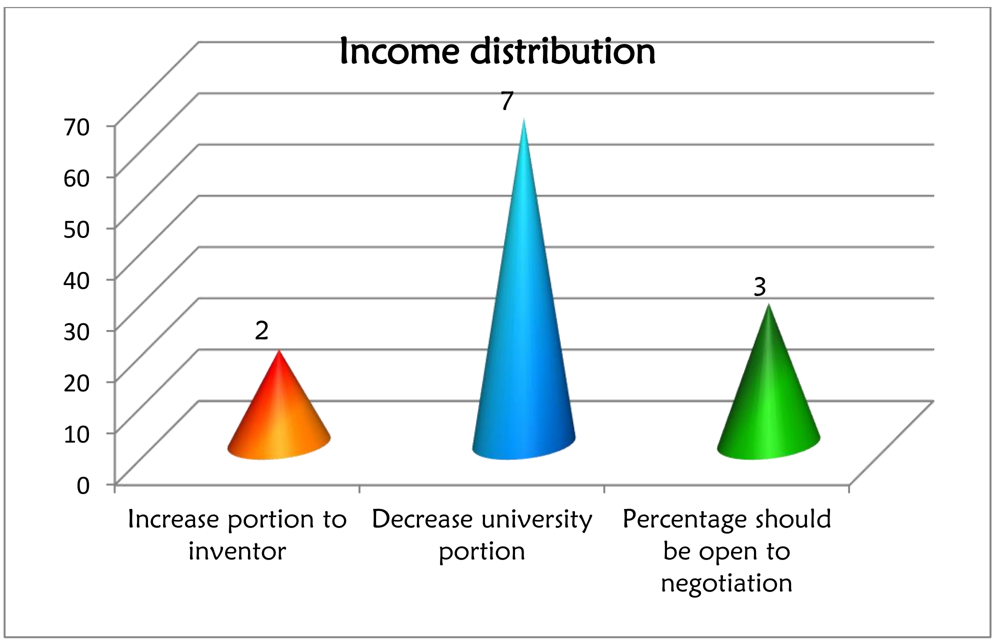

Figure 8.3: Reason for dissatisfaction with income distribution.

Seven of the innovators were of the opinion that the university portion of the income retained is too high, which only afforded a low rate of distribution to innovators.

In instances where there is limited motivation to inspire innovators to engage in commercial activity and where the barriers are too great, universities will continue to experience limited success with commercialization. Incentives such as the financial benefit to the researcher impacts on commercial activity and in turn impacts on commercial success. Siegel *et al.* (2003: 26) state that "it appears that the propensity of faculty members to disclose inventions, and thus increase the "supply" of technologies available for commercialisation, will be related to promotion and tenure policies and the university's royalty and equity distribution formula".

8.2.9 Question 9. Obstacles to commercialization

All innovators felt that there were significant obstacles to innovation commercialization; the responses to Question 10 shows the impact of these were to varying extents. It must also be noted that none of the responses indicated that there were no obstacles encountered to commercialization at their university. This implies that even if the extent was small, universities were inclined to put protocols in place that would make commercial ventures accountable. Almost half of the responses indicated obstacles to a moderate extent, and a further six responses indicated to a large extent. Responses to question 10 reveals that decision makers were unfair, IP staff not sufficiently experienced or trained in commercialization, and lack of funding opportunity.

8.2.10 Question 10: Nature of obstacles

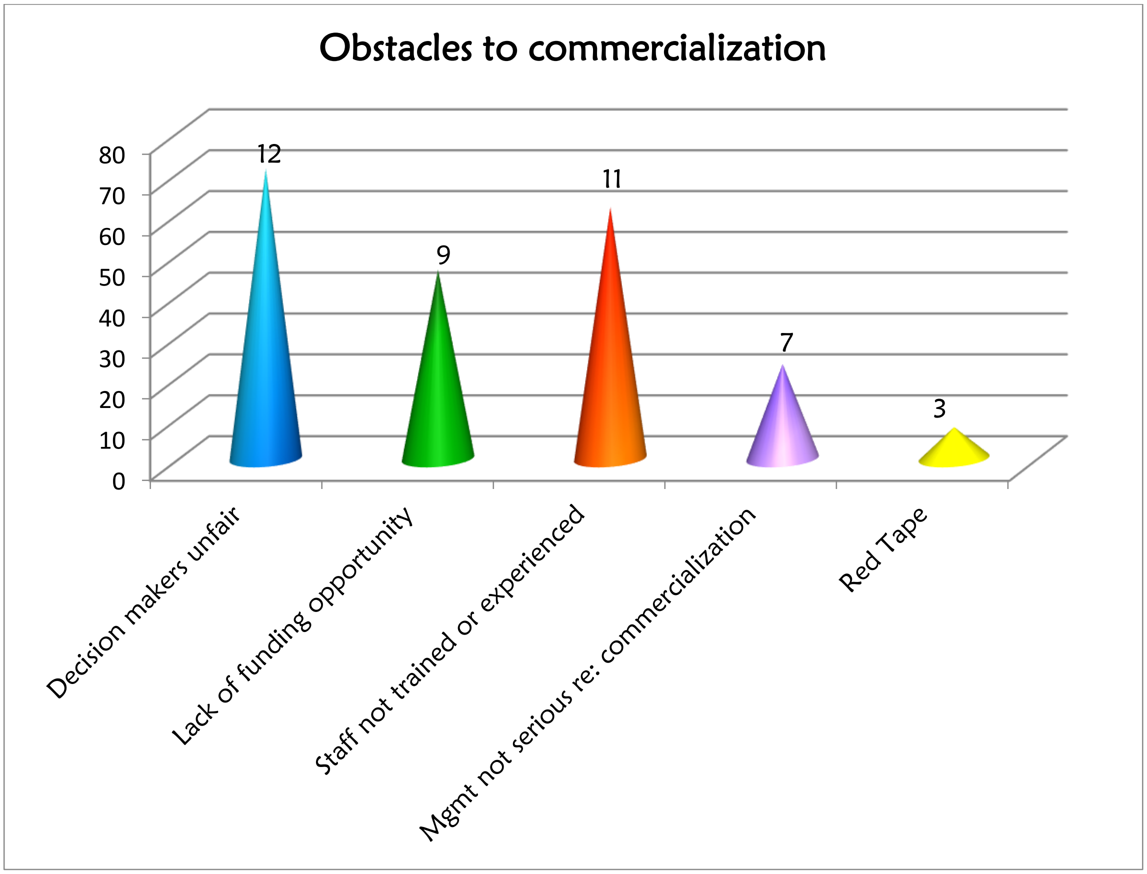

Figure 8.4: Nature of obstacles to commercialization.

Twelve of the thirteen innovators who were interviewed felt that the decision-makers were unfair. Almost two-thirds of the innovators felt that the lack of funding opportunities was a major challenge for commercialization. Funding for costly commercialization activity was generally not available. Eleven of the thirteen respondents felt that the IP&TTO staff were not experienced or adequately trained for commercialization activity. As previously discussed (see section 2.8) entrepreneurship does not come naturally to academics, therefore the need for training in commercialization. According to Haywood (2008) better patent-related services will be offered at the universities that employ high-quality, customer-oriented specialists who provide services to link the researcher with industry needs, which in turn would increase the patenting and commercialization of innovations.

A significant number of the innovators were of the opinion that university management were not serious about commercialization, leading to a general disinterest from industry to collaborate with universities to develop research products. According to Oluput's (2009: 95) study, most HEI's indicated challenges in financing the costs of patents and the lack of the right mix of staff with an entrepreneurial background (see section 2.7.2).

The main cause of inadequate funding stems from the fact that the main objectives of universities are teaching, research and outreach. As mentioned by Oluput (2009: 94), very few HEI's in South Africa therefore commercialize their innovation and of the few that do, success has been sparse.

8.2.11 Question 11: Time for commercialization activity

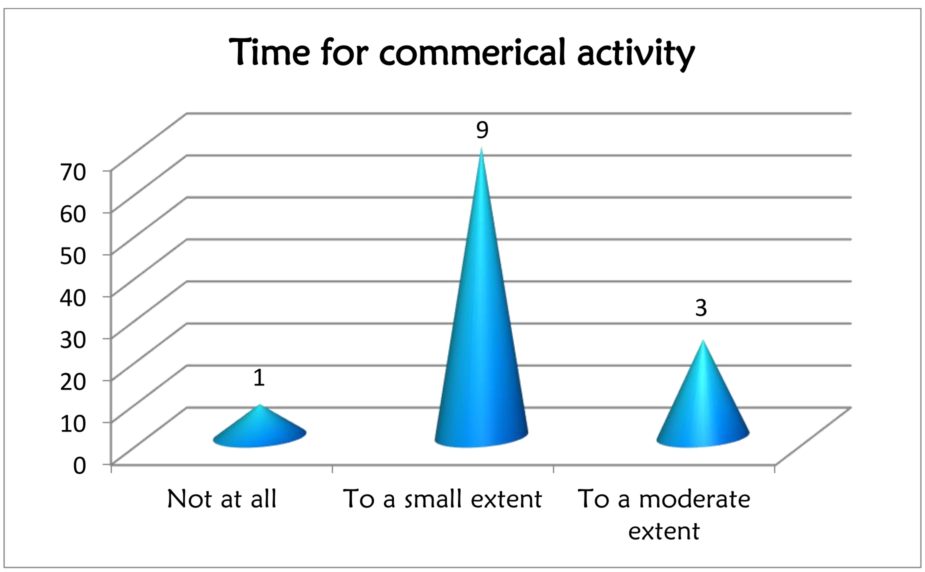

Figure 8.5: Allow time for commercial activity?

Nine of the respondents were of the opinion that innovators ought to be allowed time for commercial activity to a small extent, and a significant number of respondents felt it should be to a moderate extent.

The creator of an innovation plays a critical role in the exploitation of his or her research output, despite the ongoing dispute as to whether academic entrepreneurship should be included in the purpose of universities. The debate continues whether the university drive should remain as education for education's sake, and whether research conducted for knowledge remains just for knowledge's sake. Bok's (2003: 162) statement that "those who decry the rise of commercialization at universities, are misguided" is supported by Baxter (2011:191), who declared that in the USA context commercialization profits are generally invested back into basic research.

During the 1980's the term 'academic entrepreneurship' began to increase in scientific literature, signalling the central and leading role researchers play in the entrepreneurial processes. The term is also 'science-directed commercialization' used by Gulbrandsen and Slipersaeter (2007: 33) highlights the importance of researchers and innovators as the engines of the technology transfer process. This is reinforced by Wright, Birley and Mosey (2004: 235), who stated that, "What is clear, however, is that there is more than one route to the commercialization of university intellectual property (IP) but that, whatever the route, core to its success will be the role played by the creator of the IP, the individual scientist or engineer".

8.2.12 Question 12: Academic promotion and commercialization

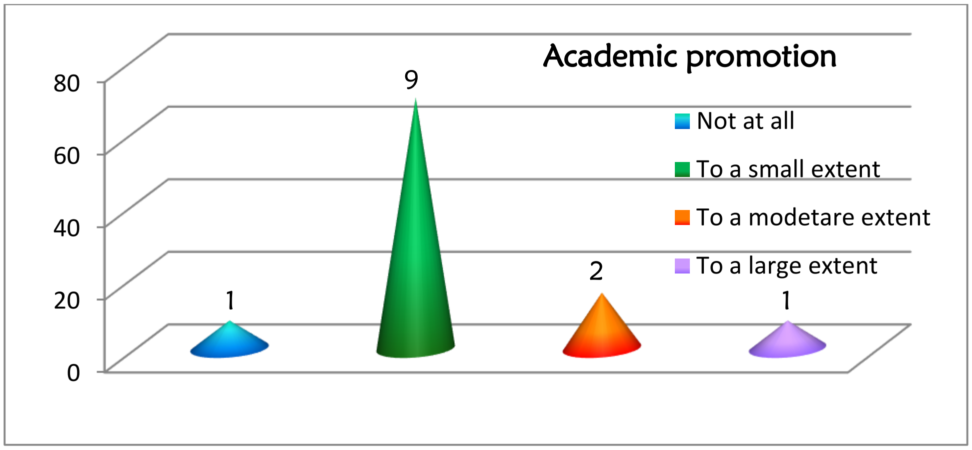

Figure 8.6: Extent of consideration for academic promotion.

The majority of the respondents were of the opinion that IP registration and commercialization ought to be a consideration for academic promotion. Lach and Schankerman (2008: 417) discovered that incentive structures such as salaries and promotion do not usually include research outputs and commercialization activity. Nelsen and Bierer (2011: 104) and Sanberg *et al*. (2014: 417) recommended that it should. Pain (2008: 1550) viewed out-of-date promotion criteria as an impediment to investment by industry, which is a vital source of funding as universities strive to diversify their research portfolios. There needs to be a change away from identifying only basic research as a promotion criterion to commercialization.

Insufficient motivation to inspire innovator participation in commercialization will ultimately result in limited success. According to Siegel *et al.* (2003: 24) for innovators to escalate the "supply" of innovation available for commercialisation, this activity needs to be rewarded by promotion, tenure policies, and the university's royalty and equity distribution formulae.

8.2.13 Question 13: University promotion of commercialization

The majority of the innovators agreed that university structures and arrangements to promote commercialization activity were non-existent.

As discussed earlier (see section 5.9.1), universities in South Africa have an obligation to commercialize innovation that stems from publicly financed funds. This obligation is regulated by the IPR Act 51 of 2008. The extent to which universities promote this activity, however, has not been documented. Commercialization has become a part of the university mission in addition to teaching and research, and may be a means of additional income generation for universities. The challenge that remains is how this will be coordinated within traditional university activities.

8.2.14 Question 14. Decision to pursue commercialization

All innovators interviewed were of the opinion that the decision to commercialize should be taken by associated stakeholders collectively. It must also be noted that a large number of the IP&TTO managers (see question 20) were also of the opinion that the decision to commercialize ought to be taken by an advisory committee. A study conducted by De Jong *et al*. (2015: 11) revealed that 43% of university IP&TTO's reported that the great challenge in innovation commercialization was selecting the innovation with which to proceed. This is a worldwide challenge. As Watanabe (2010: 205) noted, at Japanese universities most use an innovation committee, innovator and IP&TTO personnel who have already undertaken to assess the potential for commercialization.

8.2.15 Question 15: Disclosure not considered for registration

Nine of the innovators reported having IP disclosures that were not considered for IP registration. In a country where there has not been an active culture of patenting, efforts need to be directed toward developing such a culture, whilst at the same time directing efforts toward commercialization of the patent portfolios (Sibanda 2008: 11). Patenting for the sake of patenting is not adequate. Cloete, Nel and Theron (2006: 561) are of the opinion that a possible reason for the low patenting activity by South African researchers are due to, "research undertaken without commercialization in mind, and therefore lack market focus". Given that decision to register patents are typically taken by the IP&TTO, without due analysis of the likelihood of their commercialization, are granted but not exploited. Commercial potential and the route of commercialization must be considered prior to the decision of registering a patent (Ismail, Majid and Omar 2011: 82).

8.2.16 Question 16: Private patent registration

Nine innovators acknowledged having registered patents privately rather than in conjunction with the university. Among the reasons for this were the fact that ownership of the patent belongs to the university. Reasons for this decision are discussed below.

8.2.17 Question 17: Reasons for private patent registration

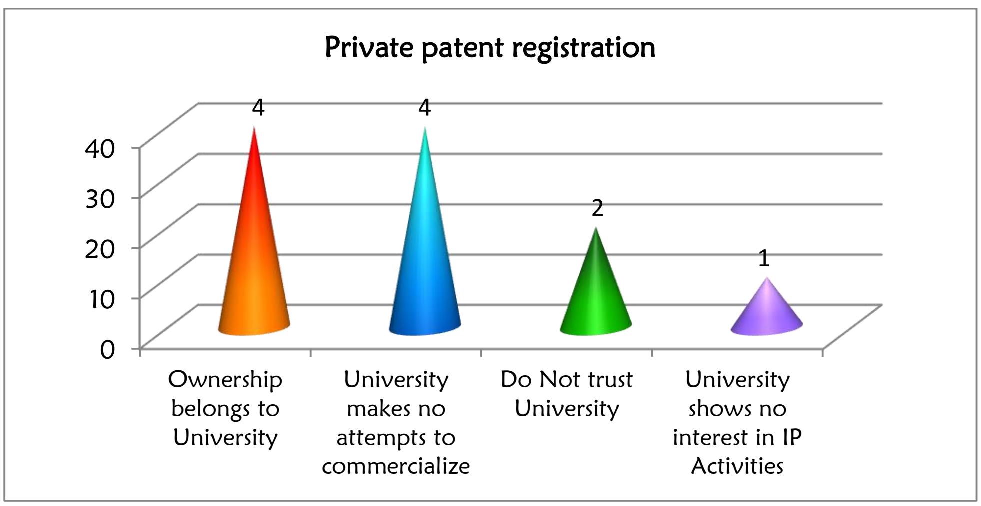

Figure 8.7: Innovators reasons for private registration.

Among the reasons for this were the fact that the ownership of the patent otherwise belongs to the university, which typically makes no attempt at commercialization. Innovators also indicated a lack of trust with the university. The significance of sincere, and trustworthy quality service offered to the innovators is crucial to commercialization success. Sibanda (2009: 1013) stated that,

> *"…the most successful commercialization efforts appear to stem from an active and dependable relationship between the IP&TTO and the innovator. Furthermore, the trust is based on the ability of the IP&TTO staff to understand the innovators' challenges, and to assist the innovator by obtaining maximum value from their research".*

Another reason for private registration was that the university displayed no interest in IP activity. The literature reveals other factors for inventors electing to register patents privately as being the perceived inadequacy of resources, and the capability of the university IP&TTO. This discourages the innovators from disclosing inventions to IP&TTO's with inadequate resources and capabilities as highlighted by Jensen *et al.* 2003: 251). The IP&TTO require staff with business development capabilities in the formation of spin-off's, as well as some business experience. Universities ought to focus on the enhancement of experience and the expertise of the IP&TTO personnel, with possible regional collaboration among universities to share the extent of knowledge and expertise (Wright *et al.* 2007: 18; Seigel *et al.* 2006: 29).

8.2.18 Question 18: Provision of internal funds for commercialization

Twelve innovators reported that the university did not make provision for internal funding such as proof-of-concept, pre-seed funding and funds for commercialization. Universities generally do not have internal funds for commercialization and largely depend on industry to fund potential innovation. For commercialization to succeed, access to funds for proof-of-concept development and to undertake detailed market evaluation is important. Where can these funds be obtained? Collier (2008: 289) revealed that universities with relatively young IP&TTOs use retained earnings to fund early-stage development. He further indicated that this method implements great discipline on the distribution of funds which may contribute towards possible solutions.

8.2.19 Question 19: Accessing external funds

Twelve of the respondents felt that the university did not assist in accessing external funds. To be successful at commercialization, the availability of early-stage funds for proof-of-concept progress and market evaluation is required. Early-stage funds are vital for embryonic concepts to be advanced to an acceptable stage before the IP can be licensed or assigned, either to industry or to a spin-off company. An industry partner who is convinced of the potential of the innovation is the logical source.

8.2.20 Question 20: Marketing of innovation to industry

The majority of the innovators felt that universities do not sufficiently market their innovations to industry for commercialization. While industry remains unaware of research output at universities, no effective innovation commercialization is likely to take place. Traditionally the prime methods of communicating new concepts developed at universities are via conferences and workshops, publication of related articles, graduated students and other academic routes. Collier (2008: 234) attested that "approximately over 95% of innovation are transferred out the university are through other methods other than the IP&TTO". For the remaining 5%, personal collaboration between the innovator and industry, supported by affiliations involving the IP&TTO, are seen as key links for success in commercial activity.

Studies such as the European Commission impact assessment indicate that insufficient collaboration between universities and industry is a barrier to the utilization of research (Productivity Commission 2009: 32). Often industry appears oblivious of the structures established by Government to boost university-industry interaction (Collier 2008: 258).

8.2.21 Question 21: Intermediaries to assist with commercialization

The majority of the innovators were of the opinion that the university did not engage with intermediaries to assist with commercialization. Although not covered in great detail in chapter 4, intermediaries have been known to play an influencing role in the commercialization of university innovation in the USA over the years (Reamer *et al.* 2003: 18). The critical function of intermediaries is also recognized by scholars such as Howells (2006: 726) and Pollard (2006:3). In Canada, however, the deficiencies of intermediaries in linking research and industry have been noted as a major impediment (Canada Federation of Students 2012: 11).

8.2.22 Question 22: Strengths and weaknesses of commercialization policy and practice

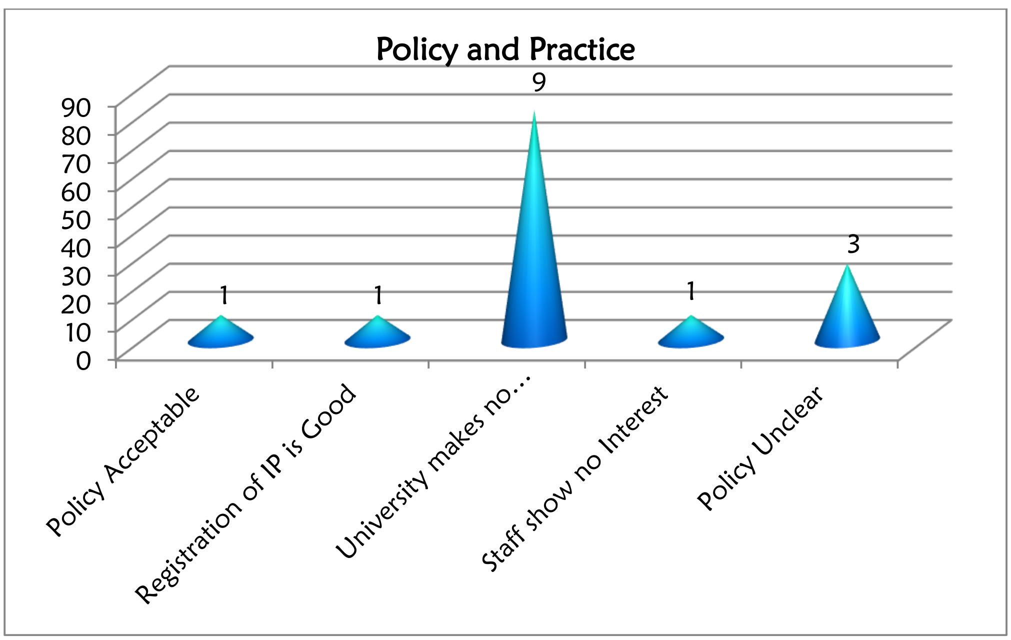

Figure 8.8: Commercialization policy and practice.

Innovators were asked about the strengths and weaknesses of commercialization practice. The most significant weakness highlighted was that the university does not make a concerted effort in the commercialization of innovation. A similar response was received from the IP&TTO managers (see question 14). Innovators were of the opinion that the universities were eager to undertake patent registration at a policy level, however there was no follow through with commercialization efforts.

Some innovators believe that the university's innovations are better managed by an external agency (Litan, Mitchell and Reedy 2008: 51), or by the innovator together with the industry partner funding the research (Foley 2012: 16). There is evidence that the most effective method of commercialization, in terms of the transfer of knowledge from the creators of innovation to industry users, are those that are sponsored and supported by industry through industry associations (Howard 2005: 19).

The level of support the IP&TTO offers with the transfer of innovation often relates to the resources and structures provided by the university (Baxter 2011: 31). With the understanding of budget constraints, the absence of appropriately qualified and experienced staff to undertake commercial activity adequately results in a low rate of successful commercialization attempts. Mulder (2013: 2) has argued that IP&TTO's in South Africa are faced with common challenges. Getting the university leaders to embrace technology transfer and commercialization activity has been the common challenge amongst IP&TTO managers and innovators equally (see also section 5.2).

8.2.23 Question 23: How to inspire participation in commercial activity

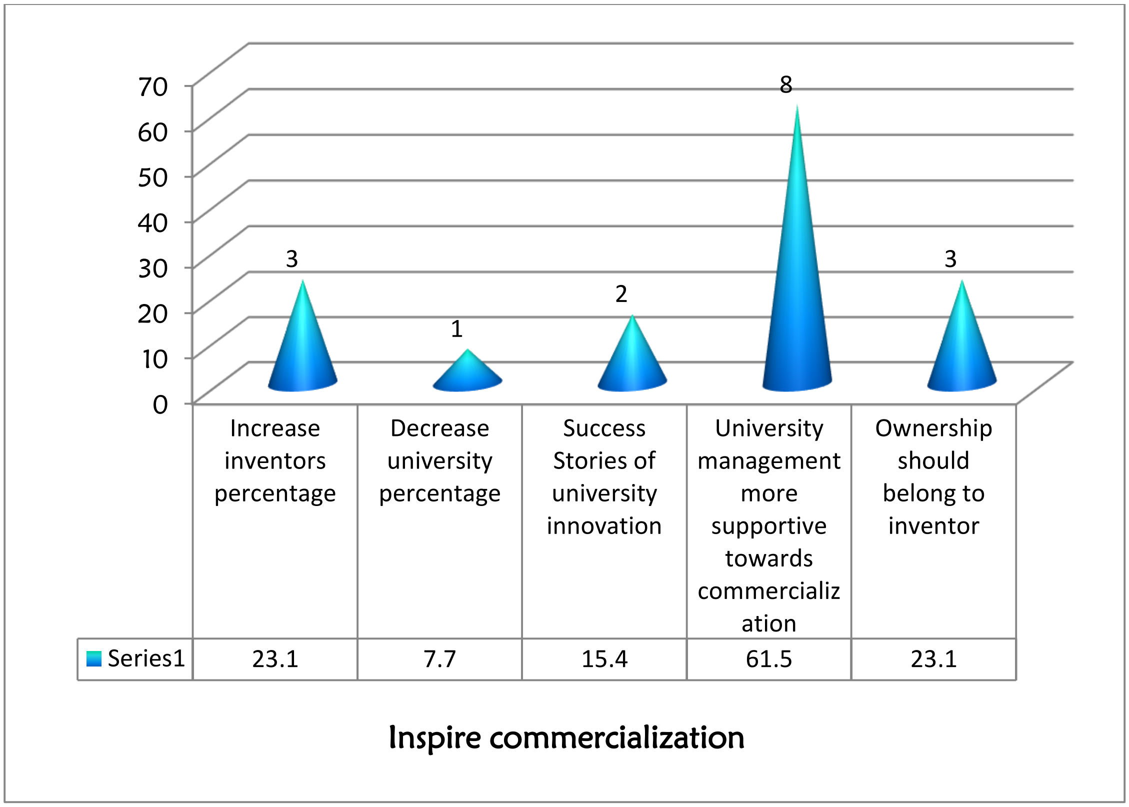

Figure 8.9 Inspiring commercialization activity.

The most common response to what would inspire innovators to participate more in commercial activity was for university management to be more supportive of commercialization. This was also highlighted by the universities IP&TTO managers (see response to questions 18 and 19). Some also felt that ownership of IP should be vested in the innovator and the innovators portion of income distribution ought to be increased.

8.2.24 Question 24: What is the appropriate role of Government?

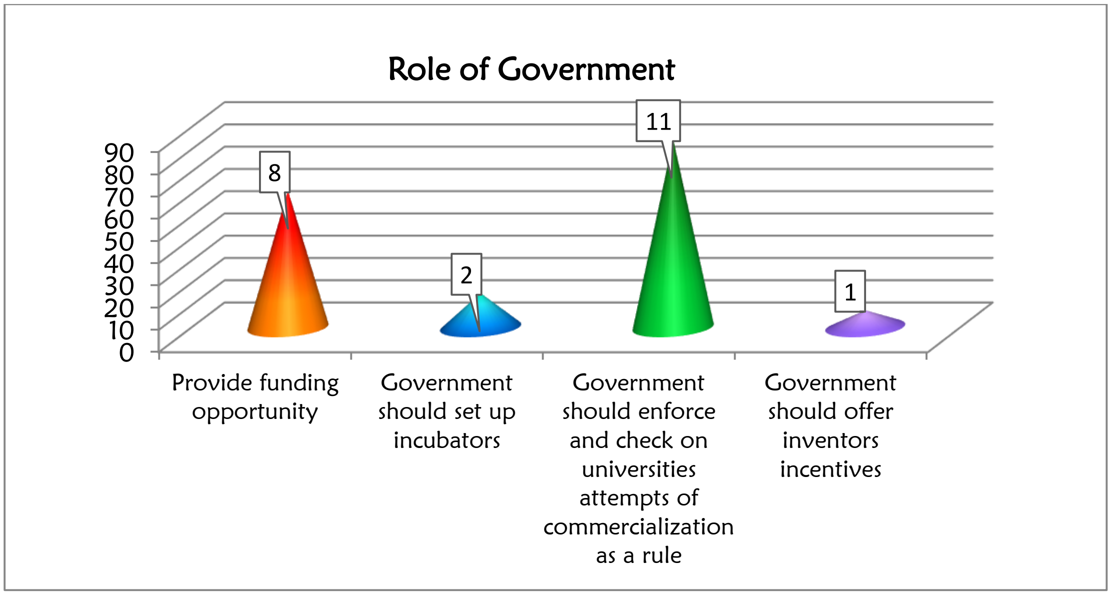

Figure 8.10 Suggested role of Government.

A large number of innovators felt that the Government ought to provide more funding opportunities to stimulate commercialization, a point also supported by the IP&TTO managers (see response to question 41). It was also highlighted that Government should ensure that universities explore commercial options more seriously. As discussed in section 5.6.1, it has been found that South Africa's IP from publicly funded research remains under-utilized. The Act regulates that recipients of public research funds have an obligation to ensure that such IP does not gather dust on the shelves, but is commercialized so that the benefits flow to the broader society.

Bozeman (2005: 632) emphasized that "government's role in commercialization ought to essentially to remove barriers to the free market, through appropriate intellectual property policies, free trade agreements, neutral impact taxation and limited regulation of enterprise". As discussed in section 3.3, the USA practice is that the Government has established a regime that encourages commercialization which allows the market to operate freely. Similarly, the role of Government in Australia (see section 3.5) and other advanced economies is limited to providing a conducive infrastructure that facilitates a smooth flow for the market to operate. The Government essentially established an environment that facilitates interaction between industry and universities. This existing practice in Australia has produced evidence that the approach can, and does, work.

8.3 Validity and reliability

As discussed in section 6.10, validity concerns whether the research actually measures what it was intended to measure and how accurate the research outcomes are. More importantly, has the research process allowed the researcher to hit "the bull's eye" of her/his research target? Reliability refers to replicability i.e. would other researchers produce similar results?

A high degree of stability in responses drawn from different data collection methods indicates a high degree of reliability. To a large extent, the responses of the IP&TTO managers supported the findings of perception and response of the innovators. Common responses between the IP&TTO managers (see section 7.3.16; 7.3.17; 7.3.20 and 7.3.39) and the innovators (8.2.10; 8.2.12; 8.2.14 and 8.2.23) included commercialization not considered a high priority by university senior management; lack of funding opportunities; no incentive for innovators to engage in commercial activity, and, the decision to pursue commercialization ought to be taken by an advisory committee.

8.4 Main findings and conclusions

The qualitative data enquiry discovered that the key challenges in commercialization were perceived to be:

- Research lacks market focus
- Research is not undertaken with commercialization in mind
- There is a lack of adequate infrastructure to commercialize research
- Commercialization not regarded as a high priority to senior university management
- There is unfairness in the process of making decisions to commercialize

The study contributes to an understanding an impediment to societal progress and provides a starting point for further research. It shows that a lack of market focus and related issues are key challenges in innovation commercialization, as previous studies have shown. In the same vein, it is confirmed that industry should encourage the building of a supply chain and this will require enhanced university-industry collaboration.

The results of these interviews show that universities with a clearly defined IP policy, a soundly structured IP&TTO and the support of senior management are likely to enjoy successful commercialization performance. The absence of an attractive incentive system, both financially and in terms of career advancement, may have driven innovators to identify with IP connections outside their own universities and, indeed, in other countries. Stronger collaboration between university and industry partners must be nurtured for South Africa to reap the benefit of investment in R&D and a consequent strengthening of economic competitiveness.

Chapter 9

CONCLUSION AND RECOMMENDATION

9.1 Introduction

This study commenced with the understanding that universities play a key role in the innovation route and should continue into the future, however this is not unfolding at the expected rate. In an ideal world, university structures should be in support of all facets of this path, from the concept stage all the way through to the ultimate commercialization success. There is a duty to nurture diverse exploration effort into patent-protected, useful and potential life-saving products and services to be transferred via licenses or start-up companies to the public. An ethos should exist that proactively embraces commercialization in support of innovation-driven fiscal enrichment. Globally, numerous discoveries are left behind at university laboratories. These concepts are in the offering to be advanced into novel technology and services for the marketplace. Yet, these unknown innovations could be the opportunity the country requires to enhance economic growth, while advancing into a strategic participant in global trade and industry. The Government's investment in R&D is not directly supported by appropriate programmes that expand the commercial potential of innovation. Research output is central to economic expansion, however seizing the full potential of innovation is a multifaceted process.

University IP&TTO's are inclined to lose finance in part, since successful innovation can take approximately ten years or more to generate an income. Although IP&TTO's may be capable of providing effective support and service to university innovators, they are often hampered by limited resources with which to strategically improve collaboration with industry partners. The IP&TTO’s are therefore limited in experience with the commercialization process and seek the assistance of industry to address prospects of funding undeveloped early-stage innovations. Significantly, as Gulbranson and Audretsch (2013: 131) pointed out, “university research does not passively spill over into innovation for commercialization”. Premature, initial stage venture markets can be unstable and inefficient, while many university innovation at an early stage are risky for investment. Additionally, most researchers lack the entrepreneurial skill to take an innovation to the market, which in turn impacts on innovation potential, viability and the funding gap. The challenge therefore is to ensure that university structures enhance and not hinder commercialization. The new type of facility that has emerged is the proof-of-concept and incubator center. This is meant to encourage transfer to the marketplace with minimal delay. This facilitates collaboration between university researchers and industry through mentors affiliated to the center. The demand to facilitate the transfer innovation from universities becomes apparent. Capacity building is necessary to accelerate academic innovations. The commercialization of innovation is a crucial activity which leads to economic development, although according to Datta (2011: 43) it remains not well understood.

This study focused on investigating contributing factors to the low rate of commercialization. This was done by focusing on four research objectives:

- To investigate the present relationship between research and the commercialization of innovation.
- To determine the ways in which innovation can be commercialized.
- To determine the cause of the apparent gap between research and commercialization.
- To propose effective ways for increasing the extent of commercialization to the potential benefit of the country.

9.2 Findings

Despite the potential, there is in fact little by way of innovation, patenting and commercialization of university research at present in SA (see section 7.3.28 to 7.3.31). The research to answer the questions which formed the basis of this study has indicated the following:

- **Objective 1 - Present relationship between research and innovation commercialization**

Decreasing Government subsidies have increased universities demands for enhanced innovative activity for sustainability. Improving the link (see section 7.3.35 to 7.3.38) between university and industry can be supportive in the relationship between research output and innovation commercialization. Innovation undertakings that support commercialization efforts very rarely result in success. This is largely attributed to poor IP management between innovation networks (see section 7.3.23 to 7.3.27). Empirical evidence suggests that trust (see section 8.2.17) affiliations between innovators and universities are challenging due to the apparent risk of disclosure, managerial intricacy and encounters of differences in culture. Other associated variables that represent trust are equally important in strategic leadership and motivation to innovate.

The generation of knowledge is undoubtedly an important aspect of innovation and long-term sustainable growth. Innovation competitiveness cannot be considered independently, it has to be supported by an infrastructure that insists on IPR's (see section 2.5). Commercialization cannot also be performed without human capital and in inefficient markets. The relationship between research and commercialization therefore has to be recognized for continued potential benefit of the university and the country collectively.

- **Objective 2 - Ways to enhance commercialization**

Prior to 2008 very little collaboration existed between universities and industry in South Africa. The IPR Act brought about the change with increased attention to commercial activity. As cultures and practices developed, universities discovered that success in commercial activity required in-depth focus and attention. Empirical evidence indicates that the typical IP&TTO at a South African university is not sufficiently equipped to manage IP and commercialization activity (see section 7.3.1 to 7.3.5). This is partly due to being understaffed with inexperienced personnel.

Success in commercialization depends largely on collaboration (see section 4.6) between university and industry researchers working towards a common goal. As Litan, Mitchell and Reedy (2008: 48) found, innovators have an insightful influence on commercialization as these individuals are the key agents of knowledge transfer. The innovator's involvement is crucial (see section 7.3.20 and 7.3.21), as the entrepreneurial turn of universities exists in the researcher himself, which is normally accepted as a vital element of fruitful commercialization. It is often found that innovations licensed from universities are embryonic in their development, and much of the worth in the innovation lies in the inferred knowledge of the innovators (Thursby and Thursby 2010: 184). Researchers tend to become more accustomed to the potential of commercial activity over time. Experience in areas such as consulting with industry, offering advisory services, industry sponsored research and formal commercialization activities, affords the researcher experience with the process that determines the direction of future research (Lee 2010: 128).

While there are various enablers of innovation at universities, the presence of strategic stakeholders (see section 7.3.20) in the network of innovation is vital. The existing definition of the ecosystem of faculty researchers and managerial leadership should be extended to include stakeholders, including industry experts, external researchers from other institutions and business service providers, to approve and accelerate innovation.

- **Objective 3 - Cause of the apparent gap between research and commercialization.**

Success in commercialization stems from university protocols supported by responsible policies. Upholding socially accountable commercialization practices of publicly funded innovation (see section 5.6) is crucial to the economic success of countries. Universities are found to possess a number of patents that are yet to be commercialized. This may be due to the complexity of the process involved in commercialization (see section 4.6). University research linked to market focus (see section 5.4) and industry requirements increases the manufacturing value chain, therefore requiring strategic alignment of both university and industry goals. Additionally, in an attempt to close the gap between innovation and commercialization applied research, patent counts, licensing and spin-off companies need to be closely monitored and audited for success. Ultimately, university industry research alignment will assist by decreasing the loss in R&D investment, and in turn increasing growth within the economy.

The IPR Act encourages increased research with commercial potential. Although the IPR Act stipulates an obligation (see section 5.9) of universities to provide proof of commercial effort, the lack of resources for commercialization hinders potential success. Reliable commercial effort is necessary to ensure utilization by the public without excessive delay. The challenge stems from innovations resulting from public funded research which are not transferred out from university laboratories. The explanations for the challenge is diverse (see section 7.5 questions 14 - 22), which include a lack of funds for prototypes; the absence of knowledge and capability to comprehend the processes of commercialization; a lack of investment to establish start-up companies; the absence of infrastructure to support new entrepreneurs; and most importantly, the absence of university commitment in support of IP and commercialization activity. Furthermore, (see section 4.6) there is an inherent mismatch between the university research focus and industry requirements, thereby increasing the gap between innovation and commercialization. In addition, (see section 2.8) entrepreneurial culture and skill is not natural to academic researchers. This is further hampered by poor incentives to innovators to engage in commercial activity (see section 7.5 questions 14 and 15, 19 and 21).

A clear perception that emerged from both the interview sessions (see section 8.2 question 9 – 13) and responses from IP&TTO managers (see section 7.3.39) was the lack of university structure and commitment in support of IP activities, which does not resonate for a conducive, stimulating entrepreneurial culture. Generally entrepreneurial ethos begins with senior management, and the failure to encourage commercial activity hampers commercialization success. This limits third stream income and slows down contributions to economic growth.

- **Objective 4 - Increasing the extent of commercialization to the potential benefit of the country**

In preparation for commercial application early-stage innovation often requires additional technical improvement for market readiness; the innovator’s tacit knowledge is therefore required. This is consistent with records from USA universities, which indicate that three-quarters of the innovations that are licensed are mainly at proof-of-concept or laboratory-scale prototype, which usually requires the innovator’s input for technical expansion (Dechenaux, Thursby and Thursby 2011: 102). This is further supported by Braunerhjelm and Svensson (2010: 117), who found patents licensed to established firms are higher if the innovator is directly associated with the commercialization process. It is thus concluded that the innovator is vital for added enhancement on innovation in order to decrease uncertainty.

Although significant advantages can be attained by building infrastructure and improving human capital, sometimes these aspects are noted to run into weakening returns. Innovation is key when integrating existing technology that tends to become outdated with time, therefore cutting-edge innovation is required to maintain a competitive advantage. This entails an environment favourable to innovative activity, supported by the university and industry collectively. This translates to mean sufficient investment in R&D particularly by industry; the presence of research intensive universities; widespread partnership between universities and industry; and the protection of IPR’s. An increase in resources and capacity building between university and industry (see section 4.6) researchers increases the skills towards entrepreneurial activity. The analysis of results from both the questionnaire and the interview session suggests that unless South African industry partners can offer access to local markets (see section 7.3.35 to 7.3.38), the risk of innovation migration to a conducive off-shore environment will remain a challenge. Stronger collaboration (see section 4.6.2) between university and industry partners must be nurtured for the country to reap the benefit of investment in R&D and a growth in economic competitiveness.

In summary, the main commercialization challenges experienced are highlighted, which are the most significant findings of this study.

- ❑ **Detecting commercially viable innovation**. Identifying commercial potential involves a combination of expertise, skill and entrepreneurial ability. The decision to patent and commercialize innovation necessitates unbiased selection criteria. University structures are found to be lacking in advisory committees for decision-making on innovation and commercial potential (see section 7.3.20 and 8.2.10).

- ❑ **Incentive to participate in commercial activity**. Results from both the questionnaires (see section 7.3.13) and the interview sessions (see section 8.2.8) recognize the significance of additional incentives to pursue commercialisation.
  Royalty distribution and academic performance appraisal is frequently based on

publication and scholarships, while efforts to commercialize seem to be disregarded. Aside from inadequate incentives to commercialize, it is found that time-consuming commercialization activity detracts from the typical undertaking of an academic who risks promotion, and this consequently turns into a disincentive. Wang and Libaers (2013: 17) recommended that engagement in commercial activity is a legitimate activity, and therefore ought not to compromise an academic's career path. The results of this study reveal that IP activity (see section 7.3.21) is not included in career advancement (see section 7.3.22) and incentive policies at most universities. It has also been identified that academic researchers lack the essential ingredient of an entrepreneurial culture to expedite commercialization, and therefore require expert advice to market innovation (see section 7.3.40 and 7.3.41). Researchers should be encouraged to think more earnestly regarding the prospects that can ascend from market focused research commercial activity. There is a requirement for specific training to improve the knowledge of all researchers on the commercialization process to enhance the ability to identify commercial applications that may stem from research results.

- **Funding the commercialisation route**. The absence of funds for the various stages of commercialization hampers innovation growth (see section 7.3.32 to 7.3.34). The proof-of-concept stage is also found to require substantial funding for product development. Innovation in its embryonic stage finds greater challenges in attracting funds.

- **The lack of local industry receptors.** This induces innovators to engage in international markets, hence the loss of IP to off-shore jurisdiction (see section 5.6.1). While immediate financial returns maybe be derived in the short term, this denies valuable growth potential and decreases the country's long-term competitiveness.

- **Lack of commitment and support by university management.** This is a significant element in commercialization, however the absence thereof was prominently evident in the questionnaire responses (see section 7.3.40) and the interview sessions (see section 8.2.23). An entrepreneurial culture begins at the top and failure to encourage this activity hampers commercialization success, thereby limiting the ability to generate third stream income and slowing down contributions to economic growth. This is complemented by Adamson (2004: 16) who identified three basic essentials that are required for effective commercialisation: implement thorough and active commercialisation processes; employ experienced staff in the IP&TTO; and distribute rewards to IP&TTO staff included to create the right motivation. Entrepreneurial transformation of universities necessitates combined entrepreneurial action including the buy-in and support of university management.

- **Market focus.** The absence of market focus in research emerged. Collaboration in the triple helix arena of the Government, industry and university necessitates increased entrepreneurial talent to effectively enhance transformation in the science and technology research landscape. It is essential that the research focus is directed by industry requirement and relevance, which justifies the usage of public R&D funds. The absence of a research focus on industry and societal needs was found to reduce success in commercialization, which is largely dependent on industry requirements.

9.3 Recommendations

Studies on commercialization have produced lengthy dos and don'ts, identifying qualities and characteristics of university IP&TTOs, and lists of resources that Governments ought to provide for success to be achieved. At best, these merely serve as guides that provide insight to varying extents that may contribute towards success. The complexities involved in commercialization makes it difficult for a proposed model to effectively work in different environments, therefore the 'one size fits all' approach will not be feasible. Some of the models include activities to be undertaken simultaneously in order to increase the chance of commercialization. With the combination of data that emerged from the questionnaire, interview sessions and reviewed literature, a linear model of commercialization does not seem sufficient. Bradley *et al.* (2013: 2) identified shortcomings of the traditional linear model which include inaccuracies such as strict linearity and oversimplified processes; a one-size-fits-all approach; an emphasis on patents; inadequate accounts of informal commercialization; failing to recognize the influence of institutional culture; and the absence of a university reward system within the model.

With the identified shortcomings in mind, the following commercialization model is proposed**:**

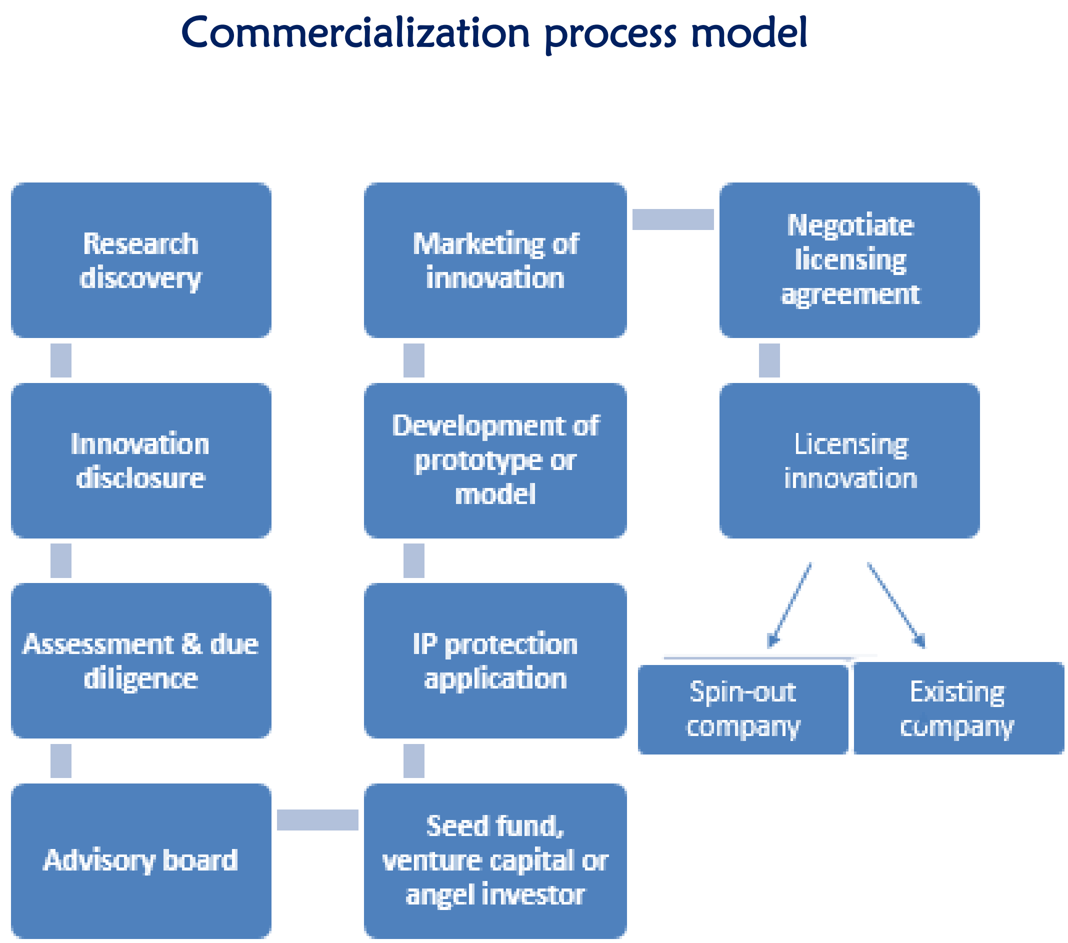

Figure 9.1: Diagrammatic representation of commercialization model.

The proposed model would operate as follows:

- ❑ **Research discovery**

  Research activity frequently lead to discoveries and innovation with the potential of commercial applicability.

- ❑ **Innovation disclosure**

  Innovator to disclose innovation to university IP&TTO within specified timeframe.

- ❑ **Assessment and due diligence**

  To ascertain competing products and whether the product satisfies a market need or creates a new market product. Decision on whether to proceed with innovation or not. On assessment of potential commercial value a preliminary commercialization strategy is drawn by IP&TTO.

- ❑ **Advisory board**

  Based on submitted strategy, an advisory committee comprising of the university faculty, university IP&TTO, Government, legal adviser, innovator and industry experts in the field of the identified innovation review disclosure and advise on a potential commercialization route.

- ❑ **Seed fund/venture capital/ angel investor**

  Application for seed funding to a potential investor or venture capital required to fund commercialization.

- **IP protection**

  The IP&TTO engage legal counsel for appropriate IP protection that acts as a deterrent from infringement and affords potential investors with security from an investment standpoint.

- **Prototype or model**

  A model or prototype is developed to demonstrate the proposed working product.

- **Marketing of innovation**

  Once IP protection has been filed, market the innovation to potential industry partners

- **Negotiate and licensing agreement**

  When a commercialization partner is identified, the decision to licence the innovation to an existing company or establish a spinout company is decided upon. Royalty distribution or equity stake is negotiated. In-depth examination of innovation may involve signing of a non-disclosure agreement.

The above process may not necessarily flow in an entirely linear direction, although the components illustrate an overview of the route to commercialization.

9.4 Conclusion

Presently, South African universities are found to be lagging behind in creating an IP culture, thereby reflecting low disclosure rates. University IP&TTO's should encourage innovators to disclose innovation internally instead of directly to industry. Increased disclosure results in a greater number of patent applications and more commercial possibilities. This hypothesis is consistent with the findings of Mellon (2011: 23) who argued that a large patent portfolio impacts on the greater probability of positive commercialization activity. It can therefore be assumed that the extent of a patent portfolio in relation to commercialization activity is an influential element in defining the commercialization performance gap.

Literature reveals (see section 3.6) that few universities generate an income from patent portfolios. It must be noted that not all Government initiatives directed at commercialization results in positive outcomes. For example, of the 500 publicly funded research projects reviewed by the Canadian Centre of Excellence for Commercialization and Research (CECR), only 80 projects displayed commercial viability. Further, only 40 proceeded with commercial intent. Ultimately, 460 research projects funded by public funds failed to harvest commercially sustainable results (Canadian Federation of Students 2012: 16). Commercialization is still to be recognized as a sustainable means to supplement university income; this is a common global challenge. As previously mentioned (see section 3.6) 60% of USA universities and 50% of British universities do not generate sufficient income from licensing activities to cover the costs of the IP&TTO's.

From the questionnaire responses from IP&TTO managers and the innovator interview sessions, it was gathered that researchers do not have a market focus and commercialization in mind. This is supported by Cloete, Nel and Theron (2006: 561) who state that low patent activity at South African universities results from "research has not been carried out with commercialization in mind and therefore lacks market focus." This is further supported by Slaughter and Rhoades (2010: 23) who argued that universities tend to converge upon similar market opportunities instead of niche competitive advantages. They further affirmed that only a few universities globally benefit from commercial activities. It is frequently found that commercial activity seldom results in revenue benefit; on the contrary, commercial activity frequently ends in financial loss.

The university environment and culture have a profound impact on the probability of commercialization success. Factors within the control of universities include conducive IP policies and practices; incentives for participation in IP activity and promotion prospects; unbiased decision making on innovation; and entrepreneurial skill and issues of risk management in the context of commercialisation. While the IPR Act was envisioned to accelerate commercialization, the Government did not adequately plan for research output in the form of innovation to be transferred from academia to the commercial market. It was anticipated that the IP&TTO's at universities would facilitate the transfer of innovation to the marketplace; instead they have become gatekeepers constraining the flow of innovation, which frustrates researchers and industry.

Governments ought to enhance university-industry collaboration via their part in funding universities. A reward system for university researchers must be set up by introducing incentives to participate in commercialization activity. Concomitantly, collaboration with industry must be encouraged. It is noted that IP transformation and commercialization energy cannot make up for a country's weak national innovation system. Appropriate technological capabilities and linkages are required before relevant returns appear in the form of commercially successful spin-off companies or licensing. Thus, low technological capacities in terms of both human capital and infrastructure, limited awareness on the benefits of IP among researchers, university management and industry, still require reform for success in innovation commercialization to become apparent.

9.5 Future Research

The commercialization of university innovation continues as a fruitful field for research specifically in economics and Government policy. Governments have a vested fiscal concern in the arena because of the substantial funding they make available to university research, and the potential such research outcomes hold for growth and economic development. It would therefore be interesting to attempt to measure the worth of the contribution to economic development.

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Appendix A

South Africa	University		Location
Cape Peninsula University of Technology			Cape Town
Central University of Technology			Bloemfontein
Durban University of Technology			Durban
Mangosuthu University of Technology			Durban
Nelson Mandela Metropolitan University			Port Elizabeth
North-West University			Potchefstroom
Rhodes University			Grahamstown
Tshwane University of Technology			Pretoria
Universiteit Stellenbosch			Stellenbosch
Universiteit van die Vrystaat			Bloemfontein
University of Cape Town			Cape Town
University of Fort Hare			Alice
University of Johannesburg			Johannesburg
University of KwaZulu-Natal			Durban
University of Limpopo			Sovenga
University of Pretoria			Pretoria

University of South Africa	Pretoria
University of the Western Cape	Bellville
University of the Witwatersrand	Johannesburg
University of Venda	Thohoyandou
University of Zululand	Kwadlangezwa
Vaal University of Technology	Vanderbijlpark
Walter Sisulu University	Mthatha

Appendix B

Dear DVC Research & Innovation

26 November 2012

RE: <u>REQUEST FOR PERMISSION TO PARTICIPATE IN RESEARCH</u>
Commercialization of innovations at universities in South Africa

The letter seeks to obtain permission for your university's IP&TTO (Intellectual Property & Technology Transfer Office) manager's participation in a questionnaire on commercialization of innovations at your respective university.

Please can this communication be forwarded to the appropriate person.

I am currently undertaking a research project as part of my studies towards a Doctoral degree in Technology: Public Management at Durban University of Technology. The study aims to analyze the nature, extent, causes and consequences of the gap between university innovations and the commercialization thereof. The research problem is an apparent lack of commercialization of university innovation. Therefore the aim of the research is to investigate the nature, extent, possible causes and consequences of this gap. The study will also focus on developing an understanding of the roles of universities in developing innovation and successfully transferring innovations to industry. In particular, the study will examine whether the universities are undertaking a proactive role in encouraging the growth of innovation into tangible outcomes and to identity the challenges faced by them in the process.

The specific research objectives are:

- ❑ To explain the present relationship between research at selected South African universities and commercialization of innovation.

- ❑ To measure the nature and extent of the gap between university research and innovation commercialization in South Africa.

- To investigate the cause of this gap, with particular attention to the alleged lack of an entrepreneurial culture at South Africa universities and to funding constraints.

- To measure the consequences of this gap to universities and the economic effects to the country.

- To propose effective ways in which the gap can be reduced, increasing the extent of commercialization of innovation to the potential benefit of the country.

The questionnaire/interview will take approximately 15 minutes. Participation is voluntary and you are free to withdraw gatekeeper permission for this project to take place at your university at any stage without giving reasons and without prejudice or any consequences. The information you provide will only be used for research purposes and will be aggregated with other responses and only the overall or average information will be used.

Your assistance will be highly appreciated.

Yours faithfully

Ramika Bansi (student)
rbansi@dut.ac.za

Prof N. Dorasamy (supervisor)
nirmala@dut.ac.za

Appendix C

DEPARTMENT OF PUBLIC MANAGEMENT - FACULTY OF MANAGEMENT SCIENCES

Commercialization of innovations at universities in South Africa Research Questionnaire

This questionnaire comprises of 8 sections, please place an x on your selected answer. Provide your opinion to relevant questions.

SECTION A - BIOGRAPHICAL DATA

1. Which of the below describes your university?

   Academic University ☐
   University of Technology (UoT)? ☐

2. Your highest qualifications?

   Undergraduate:
   Diploma ☐
   Degree ☐

   Postgradute:
   Honours ☐
   Masters ☐
   PhD ☐

3. Number of years' experience in the field of IP and commercialization activities?

0 - 5	6 - 10	11 - 15	16 - 20	More than 20

4. How long has your university's IP&TTO been in existence?

0 - 5	6 - 10	11 - 15	16 - 20	More than 20

5. How many people are employed in the office?

0 - 5	6 - 10	11 - 15	16 - 20	More than 20

SECTION B - AWARENESS OF IP LEGISLATION AND IP POLICY

The focus of the Intellectual Property Rights Act is as follows:
If a researcher has conducted research with publicly financed funding, the ownership of the intellectual property produced from such research resides with the HE institution.

6. I agree with the ownership provisions as described above.

Strongly Disagree	Disagree	Agree	Strongly Agree

7. I agree that the ownership provisions of the IP legislation as indicated above is easy to understand.

Strongly Disagree	Disagree	Agree	Strongly Agree

8. There is a need for training and development in understanding the commercialization policies for staff and innovators.

Strongly Disagree	Disagree	Agree	Strongly Agree

SECTION C - University Commercialization Environment

9. I am aware of the legislation or statutory guidelines relating to IP and commercialization environment.

Not at all	To a small extent	To a moderate extent	To a large extent

10. The vision or mission statement of your university includes commercialization activities.

Not at all	To a small extent	To a moderate extent	To a large extent

11. What percentage of income is typically retained by the university for Commercialized Innovations?

0 – 10	11 – 20	21 – 30	More than 30

12. I support my university's policy regarding the distribution of income from commercialization activities.

Not at all	To a small extent	To a moderate extent	To a large extent

13. If you answered **NOT AT ALL** or **TO A SMALL EXTENT**, please explain.

....
....
....

14. Is commercialization of IP a high priority with senior university leadership?

Not at all	To a small extent	To a moderate extent	To a large extent

15. To what extent, if any, are there obstacles to commercialization at your university?

Not at all	To a small extent	To a moderate extent	To a large extent

16. Explain possible obstacles.

....
....
....

17. The university should amend their policy, process and procedures with regard to commercialization?

Not at all	To a small extent	To a moderate extent	To a large extent

18. Explain answer to question 17?

....
....
....

19. Could the university do more to support commercialization of research?

Not at all	To a small extent	To a moderate extent	To a large extent

20. Possible solutions to above.

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……………………………………………………………………………………………………
……………………………………………………………………………………………………

21. Should the university give time off for academic staff to undertake commercialization activities?

Not at all	To a small extent	To a moderate extent	To a large extent

22. Should IP registration and commercialization results be a consideration for academic promotion?

Not at all	To a small extent	To a moderate extent	To a large extent

SECTION D - Management of Commercialization Activities

23. Is there a strong relationship between the IP&TTO and the university's research office to support commercialization?

Not at all	To a small extent	To a moderate extent	To a large extent

24. Do the present structures and arrangements at your university promote commercialization activities?

Not at all	To a small extent	To a moderate extent	To a large extent

25. Do you agree that the decision to pursue commercialization on innovation should be a collective decision involving various stakeholders

Not at all	To a small extent	To a moderate extent	To a large extent

26. Please rank the types of IP at your university (ie, what do you see the most of?):

New-to-the-world products

Not at all	To a small extent	To a moderate extent	To a large extent

New products and services that allow expansion into new customer groups

Not at all	To a small extent	To a moderate extent	To a large extent

New products and services for existing customers

Not at all	To a small extent	To a moderate extent	To a large extent

Minor changes to existing products and services

Not at all	To a small extent	To a moderate extent	To a large extent

Cost reductions for existing products and services

Not at all	To a small extent	To a moderate Extent	To a large extent

27. To what extent in each of the following business models has your university engaged in:

License to firm

Not at all	To a small extent	To a moderate extent	To a large extent

License to multinational company

Not at all	To a small extent	To a moderate extent	To a large extent

Create start-up within university

Not at all	To a small extent	To a moderate extent	To a large extent

Create start-up with investor(s) (e.g. angel, venture capital)

Not at all	To a small extent	To a moderate extent	To a large extent

Other (please specify) ………………………………………………………………….

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SECTION E – Status of registered patents

28. How many patents has your university registered since 2008?

None	1 - 2	3 - 5	6 - 10	More than 10

29. How many patents has your university successfully commercialized since 2008?

None	1 – 2	3 – 5	6 – 10	More than 10

30. From your university's attempts at commercialization, how many projects has been un- successful since 2008?

None	1 – 2	3 – 5	6 – 10	More than 10

31. For how many registered patents since 2008 has there been no attempt to commercialize?

None	1 – 2	3 – 5	6 – 10	More than 10

SECTION F - Early Stage Financing and Venture Capital

32. Does the university provide any internal funding such as proof-of concept, pre-seed, or seed for commercialization?

Not at all	To a small extent	To a moderate extent	To a large extent

33. Does the university assist the researcher to access external funds to commercialize?

Not at all	To a small extent	To a moderate extent	To a large extent

34. Does the university have standing relationships with industry or government to facilitate raising research funds to assist commercialization?

Not at all	To a small extent	To a moderate extent	To a large extent

SECTION G - Industrial Linkages

35. Does the university try to ensure that research capable of commercialization becomes known to industry?

Not at all	To a small extent	To a moderate extent	To a large extent

36. Does the university encourage research which is capable of commercialization?

Not at all	To a small extent	To a moderate extent	To a large extent

37. Does the university participate in any joint research ventures or have joint research facilities with industry?

Not at all	To a small extent	To a moderate extent	To a large extent

38. Has the university ever used an intermediary to assist in commercialization?

Not at all	To a small extent	To a moderate extent	To a large extent

SECTION H - General Views

39. What strengths and weaknesses do you observe in the university's commercialization policies and practice? ……………………………………………………………………………

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40. What would inspire universities and researchers to participate more vigorously in commercialization of research?

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41. What role, if any, do you think government should play in the research commercialization process of universities?

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Thank you for your participation!

Appendix D

DEPARTMENT OF PUBLIC MANAGEMENT - FACULTY OF MANAGEMENT SCIENCES
Commercialization of innovations at universities in South Africa Research Interview Schedule

SECTION A - BIOGRAPHICAL DATA

1. Which of the below describes your university?

Academic University ☐
University of Technology (UoT)? ☐

2. Which faculty do you belong to?

Accounting & Informatics	☐	Applied Science	☐
Arts & Design	☐	Health Science	☐
Engineering & Built Environment	☐	Management Science	☐

SECTION B - AWARENESS OF IP LEGISLATION AND IP POLICY

The focus of the Intellectual Property Rights Act is as follows:
If a researcher has conducted research with publicly financed funding, the ownership of the intellectual property produced from such research resides with the HE institution.

3. Are you aware of the ownership provisions as described above.

Yes ☐ No ☐

4. Do you agree with the above provision?

Strongly Disagree	Disagree	Agree	Strongly Agree

SECTION C - University Commercialization Environment

5. In your opinion, is commercialization a priority at your university?

Not at all	To a small extent	To a moderate extent	To a large extent

6. In your opinion, is there an entrepreneurial culture at your university?

Not at all	To a small extent	To a moderate extent	To a large extent

7. Do you support your university's policy regarding the distribution of income from commercialization activities?

Not at all	To a small extent	To a moderate extent	To a large extent

8. If you answered **NOT AT ALL** or **TO A SMALL EXTENT**, please explain.

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....
....

9. To what extent, if any, are there obstacles to commercialization at your university?

Not at all	To a small extent	To a moderate extent	To a large extent

10. Explain possible obstacles.

....
....
....

11. Should the university give time off for academic staff to undertake commercialization activities?

Not at all	To a small extent	To a moderate extent	To a large extent

12. Should IP registration and commercialization results be a consideration for academic promotion?

Not at all	To a small extent	To a moderate extent	To a large extent

SECTION D - Management of Commercialization Activities

13. Do the present structures and arrangements at your university promote commercialization activities?

Not at all	To a small extent	To a moderate extent	To a large extent

14. Do you agree that the decision to pursue commercialization on innovation should be a collective decision involving various stakeholders?

Not at all	To a small extent	To a moderate extent	To a large extent

SECTION E – Status of Registered Patents

15. Do you have invention disclosure that was not considered for IP registration?

Yes ☐ No ☐

16. Do you have any patent registered privately not in conjunction with your university?

Yes ☐ No ☐

17. Give reasons why you choose not to register with your university?

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SECTION F - Early Stage Financing and Venture Capital

18. Does the university provide any internal funding such as proof-of concept, pre-seed, or seed for commercialization?

Not at all	To a small extent	To a moderate extent	To a large extent

19. Does the university assist the researcher to access external funds to commercialize?

Not at all	To a small extent	To a moderate extent	To a large extent

SECTION G - Industrial Linkages

20. Does the university try to ensure that research capable of commercialization becomes known to industry?

Not at all	To a small extent	To a moderate extent	To a large extent

21. Has the university ever used an intermediary to assist in commercialization?

Not at all	To a small extent	To a moderate extent	To a large extent

SECTION H - General Views

22. What strengths and weaknesses do you observe in the university's commercialization policy and practice?

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23. What would inspire universities and researchers to participate more vigorously in commercialization of research?

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24. What role, if any, do you think government should play in the research commercialization process of universities?

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Thank you for your participation!

Appendix E

LETTER OF INFORMATION AND CONSENT FORM
Commercialization of university innovation in South Africa

Dear IP&TTO Manager

I am currently undertaking a research project as part of my studies towards a Doctoral degree in Technology: Public Management at Durban University of Technology. The study aims to analyze the nature, extent, causes and consequences of the gap between university innovations and the commercialization thereof.

The research problem is an apparent lack of commercialization of university innovation. Therefore the aim of the research is to investigate the nature, extent, possible causes and consequences of this gap. The study will also focus on developing an understanding of the roles of universities in developing innovation and successfully transferring innovations to industry. In particular, the study will examine whether the universities are undertaking a proactive role in encouraging the growth of innovation into tangible outcomes and to identity the challenges faced by them in the process.

The specific research objectives are:

- To explain the present relationship between research at selected South African universities and commercialization of innovation.
- To measure the nature and extent of the gap between university research and innovation commercialization in South Africa.
- To investigate the cause of this gap, with particular attention to the alleged lack of an entrepreneurial culture at South Africa universities and to funding constraints.
- To measure the consequences of this gap to universities and the economic effects to the country.
- To propose effective ways in which the gap can be reduced, increasing the extent of commercialization of innovation to the potential benefit of the country.
  process.

The questionnaire/interview will take approximately 15 minutes. Participation is voluntary and you are free to withdraw gatekeeper permission for this project to take place at your university at any stage without giving reasons and without prejudice or any consequences. The information you give will only be used for research purposes and will be aggregated with other responses and only the overall or average information will be used. Your identity and individual answers will be kept totally confidential. The questionnaire which should take not more that 15 minutes will be forwarded to you electronically once consent has been received.

Should you wish to discuss this further please feel free to contact me or my supervisor (Prof N. Dorasamy, tell 031 3736862 or Nirmala@dut.ac.za), or the IREC administration Lavisha Deonarian: 031 373 2900 or LavishaD@dut.ac.za).

Your assistance will be most appreciated.

Yours faithfully

Ramika Bansi
084 579 3132
rbansi@dut.ac.za

CONSENT FORM

Please complete the following as confirmation of your willingness to participate in this research project: I, ……………………………………………., have adequately discussed the study with the researcher, understand that I may withdraw from it at any time without giving reasons, and voluntarily agree to participate by completing a questionnaire or interview.

Signature: ……………………………….. ………. Date: ………………………………………..

DURBAN UNIVERSITY of TECHNOLOGY

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)

2 May 2013

IREC Reference Number: **REC 8/13**

Ms R Bansi
Box 701189
Durban
4000

Dear Ms Bansi

Commercialization of innovations at Universities in South Africa

I am pleased to inform you that Full Approval has been granted to your proposal REC 8/13.

The Proposal has been allocated the following Ethical Clearance number IREC 034/13. Please use this number in all communication with this office.

Approval has been granted for a period of one year, before the expiry of which you are required to apply for safety monitoring and annual recertification. Please use the Safety Monitoring and Annual Recertification Report form which can be found in the Standard Operating Procedures [SOP's] of the IREC. This form must be submitted to the IREC at least 3 months before the ethics approval for the study expires.

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the IREC according to the IREC SOP's. In addition, you will be responsible to ensure gatekeeper permission.

Please note that any deviations from the approved proposal require the approval of the IREC as outlined in the IREC SOP's.

Please note that you may continue with validity testing and piloting of the questionnaire. Research on the proposed project may not proceed until IREC reviews and approves the final questionnaire.

Yours Sincerely

[redacted]

Dr D F Naude
Chairperson: IREC