Drivers of knowledge transfer between universities and industry R&D partners in South Africa

By

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Preface documents

Abstract

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Degree: Masters in Information Science

Title: Drivers of Knowledge Transfer between universities and industry partners in South Africa

Abstract:

South Africa as a technology colony is challenged to attain industrial, technological and commercial sustainability whilst protecting its intellectual property. Universities and industry organizations are two main behavioral components of the South African National System of Innovation.

The mechanisms of how knowledge flows between universities and industry organizations are complex and multifarious. Proper management of knowledge transfer between universities and industry is crucial to alleviate the technology colony dependency and to move toward a stable and reliable knowledge exchange system.

This dissertation presents the findings of the RESEARCH MARKETING & TECHNOLOGY COMMERCIALIZATION SURVEY conducted in South Africa. Part IV of the survey has been designed to examine the mechanisms of knowledge transfer between industrial organizations and universities on research and development (R&D) collaborations. A study on the drivers of knowledge transfer in particular is presented in this dissertation.

Keywords: Knowledge transfer drivers, university/industry relationships, National Systems of Innovation (NSI).

Samevatting

Kandidaat: Anthea Van Zyl

Supervisors: Professor Joe Amadi-Echendu and Professor Theo Bothma

Departement: Inligtingkunde

Graad: Meesters in Inligtingkunde

Titel: Die drywers van kennisoordrag tussen universiteite en industrieë in Suid-Afrika.

Samevatting:

Suid-Afrika as a tegnologie kolonie word uitgedaag om industriële, tegnologiese en kommersiële lewensvatbaarheid te behaal en te behou, terwyl die land se intellektuele eiendom beskerm word. Universiteite en industrie-vennote is twee hoofrolspelers in die Suid-Afrikaanse Nasionale Sisteem van Innovasie.

The meganismes van kennisoordrag tussen universiteite en industrie-vennote is kompleks en veelvuldig. Pro-aktiewe bestuur van die proses is belangrik in die strewe daarna om ons land se tegnologieafhanklikheid om te keer en om te beweeg na ‘n stabiele en betroubare kennisoordragsisteem.

Hierdie verhandeling lê die bevinding van die NAVORSINGBEMARKINGS- EN TEGNOLOGIE KOMMERSIALISERINGSOPNAME voor wat in Suid-Afrika gedoen is. Afdeling IV van die opname is ontwerp om die meganismes van kennisbestuur tussen industrieë en universiteite rondom navorsing en ontwikkelingsamewerkings-ooreenkomste na te vors. Die data ten opsigte van die drywers van kennisoordrag in besonder, word ontleed en bespreek.

Sleutelwoorde: Drywers van kennisoordag, universiteit-industrie verhoudings, tegnologiekolonie, Nasionale Sisteem van Innovasie (NSI).

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Table of Contents

List of Figures

List of Tables

List of Acronyms

DoE: Department of Education

DST: Department of Science & Technology

DTI: Department of Trade & Industry

FET: Further Education and Training

HEI: Higher Education Institution

HRD: Human Resources Development

HSRC: Human Sciences Research Council

ICT: Information and Communication Technology

IDC: Independent Development Corporation

IF: Innovation Fund

IPRs: Intellectual Property Rights

NGOs: Non-governmental Organizations

NRDS: South African National R&D Strategy

NRF: National Research Foundation

NSDP: National Skills Development Plan

R&D: Research & Development

S&T: Science and Technology

SAQA: South African Qualifications Authority

SET: Science, Engineering and Technology

SETI: Science, Engineering and Technology Institutions

SMMEs: Small, Medium and Micro Enterprises

THRIP: Technology and Human Resources for Industry Programme

TIPTOP: Technology Innovation Programme through the transfer of people.

List of Appendices

Glossary of Terms

Data, Information & Knowledge

Blumentritt & Johnston (1999:287-298) write that *data* are unstructured facts without meaning, while *information* is data endowed with relevance and purpose. It can be captured, stored and transmitted in digital form and can be utilized in various applications, such as intranets, groupware, list servers, knowledge repositories, databases and action networks; *knowledge* again can embody cognition, insight, erudition and scholarship, and wisdom is a consequence of the fusing of knowledge with values and experience. Knowledge includes reflection, synthesis and context. To this Davenport et al (1998:43) adds that knowledge is information combined with experience, context, interpretation, and reflections.

Knowledge Types & Components

The two main groupings of knowledge are those of explicit and tacit knowledge. Based on Fleck's table (1997:384) the different Knowledge Types can be depicted as follows:

Knowledge Type	Description
Common Knowledge	Dixon (2000) in his book, *Common Knowledge*, classifies *knowledge* as, 'far, explicit, embodied, encoded, embrained, embedded, event, procedural and common.' • Common knowledge is knowledge that employees obtain from doing the organization's tasks; • Common knowledge is based on the intended receiver, the nature of the task and the type of knowledge.
Formal Knowledge	• Formal knowledge is usually acquired through formal education; • The fields of science, technology, medicine and law focus on formal knowledge; • These fields require distinctive and extensive bodies of formal knowledge;

	• Formal knowledge is embodied explicitly in codified text, theories, formulas, diagrams, in dense symbolic inscriptions and in protracted processes; • Formal knowledge is usually available in written form, for example a textbook; • This type of knowledge is made significant through the interpretation of human experts, because people are able to mobilize the meaning of the information (Fleck, 1997:385).
Instrumental Knowledge	• Instrumental knowledge is embedded in tools and instruments and in their correct use; • Instrumentalities include knowledge about practical operation, maintenance and limitations, which extend far beyond the basic physical technological components themselves (Fleck, 1997:387); • This type of knowledge is informal, tacit and contingent in nature; • It is learnt through demonstration and practice and is effective for mobilization; • Fleck (1997:386) attributes instrumentalities to dramatic scientific discoveries (such as the electron microscope) and says that 'instrumentalities are a significant route for mutual interaction between engineering, science and technology, and constitute one of the key mechanisms by which technological innovations enter into, and help shape scientific development.' Note: The need for novel technological configurations and innovation in South Africa calls for formal theoretical knowledge to become a generating activity.
Informal Knowledge	• Informal knowledge is concerned with heuristics i.e. *rules of thumb* or *tricks of the trade* and is learnt on the job over a period of time; • Informal knowledge is transmitted best in verbal interactions, within a specific milieu, because such interactions are more flexible; • Informal knowledge is available in verbal and written form e.g.

	guide books and manuals; • If informal knowledge is articulated, it may become explicitly available in written form. It is then readily tradable (Fleck, 1997:387).
Contingent Knowledge	• This type of knowledge is trivial and distributed, but is embodied in a specific context; • Sometimes contingent knowledge is available as data, which can be looked up, but more often than not, it is acquired through on-the-spot learning; • Fleck (1997:383-4) introduces 'contingent knowledge as knowledge, which is embodied in the working context (e.g. military intelligence / industrial espionage), which is given meaning by knowledgeable agents,' thus 'any given body of expertise, made up of a range of components,' works together in the effective deployment of the expertise, but the critical point is that they are all 'integrated through human agency'; In a business or commercial context *contingent knowledge* has the following characteristics: (a) Contingent knowledge differs from formal knowledge in that it lacks systematic codification and is concrete rather than theoretical; (b) It is distributed; (c) It is apparently trivial; (d) It is highly specific to the particular application domain; (e) Consequently it is accidental to the general process of technology development; (f) It has a close familiarity with the operations involved in technology implementation as well as the idiosyncrasies of the existing equipment and organization; (g) It is extremely voluminous; (h) It is widely distributed through an organization and in networks of contacts between organizations; (i) It is often embodied in organizational memory resources; (j) It is often overlooked or undervalued; (k) It requires on the spot learning; (l) It is more accidental, and less systematically arrayed

	around some set of tasks or technologies; (m) It is often not perceived to be relevant, solicited, valued or acted upon; (n) Contingent knowledge is embodied in the context itself, sometimes in physical devices such as filing cabinets and notice boards (and even street signs), and sometimes as factual knowledge embodied in people's memories and distributed over networks of contacts; (o) 'Successful technology implementation and development requires the harnessing and exploitation of contingent knowledge, but because of its distributed, accidental and under-valued character, it is not always easy' (Fleck, 1997:390-4).
Tacit Knowledge	• Tacit knowledge is rooted in practice and experience; • Tacit knowledge is embodied in human beings; • Tacit knowledge is transmitted via apprenticeships and training; • Blumentritt & Johnston (1999:287-293) quoting Marshal & Courtney say that, 'knowledge is in the mind and information is outside the human mind. Information becomes knowledge when introduced into one's mental model'; • Tacit knowledge transfer is tricky; • Davenport et al (1998:43) explains saying, 'unlike data, knowledge is created invisibly in the human brain (i.e. tacit), and only the right organizational climate can persuade people to create, reveal, share and use knowledge. Data and information are constantly transferred electronically, but knowledge travels most felicitously through a human network.'
Meta Knowledge	• Meta knowledge is embodied in organizational philosophies, assumptions, and values; • Meta knowledge is acquired through socialization.

Cultural Knowledge	Sackman (1991) quoted by Fleck (1987:389), breaks cultural knowledge down into the following sub-categories: • The definition of things and events (dictionary knowledge) • Expectations (directory knowledge) • Prescriptions for action (recipe knowledge) • Fundamental beliefs (axiomatic knowledge).

Table 1: Knowledge Types

Knowledge Management

Knowledge Management is a fluid mix of framed experience, values, contextual information and expert insight that provides a framework for evaluating and incorporating new experience and information. It originates, and is applied, in the mind of knowers (Davenport & Pruzak, 1998). The management of knowledge therefore includes the process of capturing, appreciating, sharing and distributing knowledge (Karlsen & Gottschalk, 2003:112).

Knowledge management is a collection of processes that govern the creation, dissemination, and utilization of knowledge in an organization (Newman, 1991). Ajiferuke (2003:1) adds that knowledge management involves the management of explicit knowledge (i.e. knowledge that has been codified in documents, databases, web pages, etc.), and the provision of an enabling environment for the development, nurturing, utilization and sharing of employees' tacit knowledge (i.e. know-how, skills, or expertise).

Knowledge Transfer

Organizational knowledge is complex, accumulated expertise that resides in individuals and is partly or largely inexpressible (Karlsen & Gottschalk, 2003:112). This is because organizations operate as *distributed knowledge systems* (Tsoukas, 1996:11) and contain within them various streams of knowledge (Von Krogh & Roos, 1995:57).

Inter-organizational knowledge transfer according to Argote et al (2000:7) is the process in the organization by which one unit (e.g. individual, group, department, division, etc.) is affected by the experience of another. This affects the performance

of the recipient units knowledge repositories in general and the potential outcomes of knowledge transfer (Argote & Ingram, 2000:152).

The management of knowledge therefore includes the process of capturing, appreciating, sharing and distributing knowledge, while technical expertise in many organizations has become a scarce and costly commodity; 'expert transfer has become a convenient, workable and important way to share expertise that may be located anywhere in the world' (Karlsen & Gottschalk, 2003:112, 117).

Defining Research & Development (R&D) Projects

According to the Frascati Manual, research and experimental development is creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of humanity, culture and society, and the use of this stock of knowledge to devise new applications (Kahn, 2005:10).

A research and development project between a university and an industry partner can be seen as a complex effort to achieve a specific objective within a schedule and budget target, which typically cuts across organizational lines, is unique and is usually not repetitive (Cleland & King, 1983). One reason for this is that knowledge of one context is often applied (or fails to apply) to another and the knowledge is instinctively modified in applying it within the new context, but this is by no means a simple process (Singley & Anderson, 1989:1).

Within universities and industry firms a variety of projects take place concurrently, and in these projects knowledge is being transferred continually within the plans, activities, milestones (aims or goals) and responsibilities, or roles, of both units and individuals. Karlsen & Gottschalk (2003:113) observe that communication processes and information flows drive the knowledge flows through formal and informal channels as well as personal and impersonal channels.

Defining Innovation

Marcus (Industrial Innovation in SA, 2003:3) defines innovation in the South African context as the process of transforming an idea, generally generated through research and development, into a new or improved product, process or approach, which relates to the real needs of society and which involves scientific, technological, organizational or commercial activities.

The working definition employed for this research project is that innovation, as an interactive, but non-linear activity aims to transform entrepreneurial ideas through actionable R&D in order to introduce new need-meeting and benefit-providing product and service inventions to the commercial market.

Drivers of Knowledge Transfer

In order to compile a working definition of the three terms used by industry and academics – namely knowledge transfer *mechanisms*, *drivers* and *indicators*, the COLLINS ENGLISH DICTIONARY: MILLENNIUM EDITION (1999) was consulted.

- The COLLINS ENGLISH DICTIONARY (1999:965) defines a mechanism as 'a system or structure…that performs some function; or a process or technique of execution.'
- The COLLINS ENGLISH DICTIONARY (1999:784) defines an indicator as 'something that provides an indication of trends; a device to attract attention; an instrument that displays certain operating conditions; a device that records or registers something; or that shows information.'
- (c) The COLLINS ENGLISH DICTIONARY (1999:473) says that a driver 'can be a force that is in control or an instrument that exerts force to produce movement or provides input.'

Cloete & Bunting (2000:3) write that *indicators are tools* used either to describe or to evaluate the state of a system at a particular point in time. Indicators can be divided into the broad categories of *descriptive indicators* and *performance indicators*.

- *Descriptive indicators* are a subset of the broad set of empirical descriptions, which are sentences, which can be termed true or false, reliable or unreliable. So this type of indicator acts as a pointer or guide to some complex properties of the system concerned.

- A *performance indicator,* on the other hand, judges the performance of e.g. government and as such serves an evaluative function. The aim of a performance indicator is to point toward the intended or planned consequences for the functioning of a system.

The *working definition* of a knowledge transfer driver is the following: A Knowledge Transfer Driver refers to an instrument, descriptor, indicator, behaviour, perception or device, which aids in transferring knowledge.

Technology Commercialization

Some industry firms, which engage universities in R&D, do so in order to explore the possibilities of being able to commercialize their products and/or services. Technology forms part of an 'evolutionary process' according to Henderson et al (1998:122), and these authors write that 'the significance of an invention is evidenced by its role in stimulating and facilitating future inventions'. In clarifying the second part of the term, *technology commercialization*, Siegal et al (1999:19) defines commercialization as to mean 'converting or moving technology into a profit-making position. And by technology we are referring to know-how, techniques, patented or otherwise proprietary process, materials, equipment, systems, etc.'

Its kind of fun to do the impossible!

(Walt Disney)

CHAPTER ONE

INTRODUCTION & BACKGROUND

The purpose of this Masters dissertation in Information Science is to explore various knowledge transfer drivers between universities and industry partners. The focus is on the relationship between South African universities and local industry partners with whom they have research and development (R&D) collaborations. Industry firms are seen as buyers of research. For the purposes of this research dissertation the working definition of a knowledge transfer driver, is the following: A knowledge transfer driver refers to an instrument, descriptor, indicator, behaviour, perception or device, which aids in transferring knowledge.

This chapter will be devoted to discussing National Systems of Innovation, the interface between Higher Education Institutions and Industry; reference will be made to the Triple Helix Model, the Research-to-Innovation Value Chain and the Technology Colony concept. From there the focus will move to the South African landscape of Science & Technology, with corroborating statistics. The chapter will conclude with a section on the research strategy to understand what drives R&D collaborations between industry firms and universities, followed by the structure of the research project itself.

Problem Statement: What are the predominant drivers of knowledge transfer in the interface between industry firms in South Africa and universities with whom they have R&D collaborations? In attempting to answer the main research question, the following sub-research questions will be addressed:

- What does literature reveal on the drivers of knowledge transfer which exist between industry firms and universities?
- What are the global and national perspectives of past and current relationships between industry firms and universities?

- What is the impact and effect of knowledge transfer drivers on industry firms in their R&D collaborations with universities in South Africa?

- What is the impact and effect of knowledge transfer drivers on universities in South Africa and the way they position themselves in R&D collaborations with industry partners?

1.1 The National System of Innovation (NSI)

1.1.1 Models of Systems of Innovation

The South African WHITE PAPER ON SCIENCE & TECHNOLOGY (1996, Chapter 3) defines a NSI as follows: 'A National System of Innovation can be thought of as a set of functioning institutions, organizations and policies, which interact constructively in the pursuit of a common set of social and economic goals and objectives.' The document further states that a National System of Innovation can only be judged as healthy if the knowledge, technologies, products and processes produced by the national system of science, engineering and technology fraternity have been converted into increased wealth, by industry and business, and into an improved quality of life for all members of society. It is acknowledged that knowledge transfer in general, and technological, technical and R&D knowledge in particular, is extremely important between the stakeholders of the Triple Helix. The Triple Helix of university, industry, and government, explain Leydesdorff & Etzkowitz (2001:1, 9), provides input and sustenance to science-based innovation processes, and this network system of interactive spirals engages to promote economic development and academic research. Etzkowitz & Leydesdorff (2000:109) write that university research may function increasingly as a locus in the laboratory of such knowledge-intensive network transition as is seen between academia, industry and government in the Triple Helix model components of a NSI.

Ngubane (NRDS, 2002:5) perceives that the role of a National System of Innovation should be to promote better governance, more

effective resource allocation and better outcomes in the short, medium and long term. National Systems of Innovation are all about partnerships in which new knowledge is created and transferred; innovations are produced and then diffused to the benefit of all the people of South Africa. Mytelka (2003:31), who defines an innovation system as 'a network of economic agents, together with institutions and policies that influence their innovative behavior and performance,' also points to the importance of policy making issues, which can be a by-product of the research results produced by this project.

A national innovation system according to the definition provided by Balzat & Hanusch (2004:197-8) can be perceived as a historically grown sub-system of the national economy in which various organizations and institutions interact with, and influence one another, in the carrying out of innovative activity. Based on the elements of these definitions given above, Etzkowitz & Leydesdorff (2000:115) are of the opinion that innovation systems should be considered as the dynamics of change in both production and distribution systems. Such dynamic systems of innovation explain Godin & Gringras (2000) 'may consist of increasingly complex collaborations across national borders and among researchers and users of research from various institutional spheres.' It is important to keep in mind that the infrastructure of knowledge-intensive economies implies an endless transition, particularly when knowledge is increasingly utilized as a resource for the production and distribution systems. This endless transition is due to the fact that the structure of the national systems of production and innovation is a 'product of a historical process' according to Lundvall (in Dozi et al., 1988:361).

Policy makers perceive the concept of national innovation systems as a means to derive technology policy measures, which can improve the organization of innovation processes at national level (Balzat & Hanusch, 2004:198). The functioning of research streams within the national innovation system are described by terms such as *innovative performance* and *innovative efficiency* [i.e. defined as a ratio of output

to input], as indicated by Balzat & Hanusch (2004:207-8), so basically, the functioning of a national system of innovation is identified by its ability to generate innovative outcomes or by the intensity of linkages between the main elements in its innovation processes.

The science and technology capacity of a country can be defined as 'the ability of a country to absorb and retain specialized knowledge and to exploit it to conduct research, meet needs, and to develop efficient products and processes' (DST, 2005:60); within a national system of innovation, *capacity* consists of seven features and these capacity features are:

- Infrastructure to support economic and research activity;
- Educated people at the tertiary level;
- Sufficient scientists and engineers in R&D;
- Research institutions;
- Funds which are spent on R&D by public and private sources;
- A stock of embedded knowledge within institutions; and
- Connectivity with the larger science and technology world.

This science and technology capacity within a national system of innovation, hold certain implications in terms of policy and planning. A linear concept of knowledge creation (from basic research to the marketplace) is inadequate to manage science and technology because increasingly, research is networked, spans disciplines and political borders, and includes participants from different sectors (such as university and industry researchers in common research projects). Each of these factors adds a measure of complexity to those seeking to do policy planning, monitoring and evaluation (DST, 2005:63).

In discussing the various interpretations of a National System of Innovation, Makar (2003:31) contributes a broader definition, which touches on the commercialization aspect - the desired end-result of technological knowledge transfer. Makar defines a National System of Innovation as 'the network of public and private institutions that fund and perform research and development, that translate the results into commercial innovations and affect the diffusion of new technologies.'

With R&D as the premise, South Africa is characterized by a mixed National System of Innovation (NRDS, 2002:25). This means that the private sector, higher education and government perform a roughly equal amount of R&D. The key function of a robust NSI lies in its ability to span the value chain from research to product and the full range of institutions from academia, to high-technology start-ups and large enterprises. According to NRDS (2002:64-65), effective National Systems of Innovation are serviced by the following three functions:

- A programme for the funding of fundamental research mainly to develop human capital and new knowledge;
- A programme to promote innovation, technological development and diffusion;
- A programme (often incorporating venture capital) to promote the commercialization of research results (oriented to higher economic growth rates).

Currently in South Africa, basic and thematic research is funded by the DEPARTMENT OF SCIENCE & TECHNOLOGY (DST) via the NATIONAL RESEARCH FOUNDATION (NRF), and by the DEPARTMENT OF EDUCATION (DoE) in terms of formula-based research funding to Higher Education Institutions (HEIs). This point will be expounded upon later.

1.1.2 The interface between Higher Education Institutions and Industry

Bowen (1980:17) argues that universities have as their core goals the pursuit of ever-increasing educational excellence, prestige, and influence (e.g. published rankings and calibre of students) and that higher education has an insatiable appetite for new revenue sources; hence institutions try to raise all the monies they can with the purpose of increasing the institutions excellence, prestige, and influence. 'Excellence' within Bowen's *Revenue Theory of Cost* (1980:17) implies that an institution will actively pursue a commercialization agenda that will enhance their legitimacy through demonstrated alignment with practical societal needs.

In dynamic environments, inter-organizational initiatives are powerful because they enable organizations to share risks, build on jointly shared capabilities, and create synergies for better competitiveness (Cyr in Santoro & Gopalakrishnan, 2001:163). One aspect that advances competitiveness within firms is the manner in which firms manage and transfer knowledge. In this respect Von Krogh, Nonaka & Aben (2001:421) highlight the following four strategies found within firms. Successful firms are able:

- To leverage knowledge throughout the organization;
- To expand knowledge based on existing expertise;
- To appropriate knowledge from partners and other organizations; and
- To develop completely new expertise by probing new technologies or markets.

Knowledge management as motivated by McInerney & LeFevre (in Prichard et al., 2000:16), is best practiced in situations that are collaborative and team-oriented, but the important thing is that firms must treat knowledge and the people responsible for it in fair and just ways that engender trust and confidence in the systems that are

established. It should be kept in mind that industry is not very dependent on universities for research (Blevins & Ewer, 1988:652) as many firms have their own R&D divisions. While a university should not ignore the potential availability of funds from commercial sponsors, warns Giamatti (1982:1278), neither should it be driven to arrangements that are not compatible with the norms and mission of the university. Another author, Owen-Smith (2003:1082) writes that faculty responses to commercialization manifest the complexities inherent in managing sometimes-contradictory commitments.

What drives firms to collaborate with universities?

This is the crucial question posed by this research dissertation. According to Levin et al. (1987:783) one possible answer is the following: To have the incentive to undertake research and development, a firm must be able to appropriate returns sufficient to make the investment worthwhile. In a further attempt to address this question comments made by respondents to a HSRC survey (2003:121-122) indicate that the following factors are worthy of consideration:

(a) Industry have need of workshops where potential industry and Higher Education partners can meet and review the possible benefits of such a relationship;

(b) Industry need access to data which will indicate what expertise is available at Higher Education Institutions;

(c) Industry desire to share published information on technological innovations;

(d) Industry require longer term financial commitments from funding agencies;

(e) Industry also require increased funding of projects to facilitate increased collaboration;

(f) Industry want greater flexibility in the administration of these funds;

(g) Industry want Higher Education Institutions to focus more on product development; and

(h) Industry need help in matching specific industry requirements with corresponding expertise at Higher Education Institutions.

In theory these requests are plausible, but Bok's (1990:21) opinion is that contact with industry may create special dangers for the type of academic environment needed for basic research. One reason is that companies may insist on secrecy requirements to protect proprietary information. Furthermore the lure of commercial success can induce talented faculty members to spend too much time starting a company or consulting with established firms, so that the quality of their basic research may begin to suffer. It is even possible that some professors will exploit their graduate students by persuading them to work on commercially valuable research rather than projects of greater academic value. Carried to excess, such practices could corrupt basic research and eventually weaken it significantly.

What are the requirements for collaborations in the opinion of industry firms? According to Feller (1990:337-8) the following conditions apply:

(a) Scientific advances must have industry-creating potential;

(b) There must be a large or dominant role for academic scientists as a source of this new knowledge; and

(c) A venture capital market willing to invest in the long-term economical potential of basic research must also exist.

It is evident, in the opinion of Feller (1990:338) that the boundary markers of academic research are being moved by attitudinal changes akin to speculative bubbles on the part of entrepreneurial

faculty, because patterns of university-industry arrangements are shifting away from direct investment in long-term university-based research programs, towards consulting and contract research. This tendency has not left South African universities unaffected.

Industry respondents surveyed by the HSRC (2003:66) were asked to indicate the reasons why their enterprise desired to engage in partnerships with Higher Education Institutions. The responses are displayed in Figure 1 below.

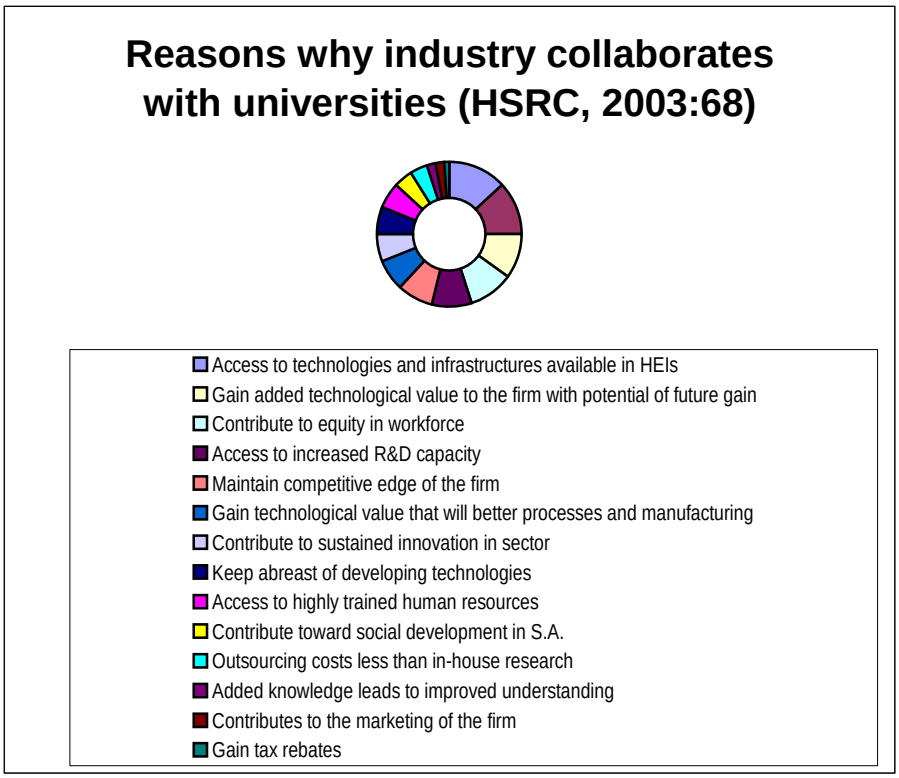


Figure 1: Reasons why industry collaborate with Higher Education Institutions (HSRC, 2003:68)

Contrary to expectations, items relating to financial gain and increased profitability do not appear as the top two motivations for the relationship with Higher Education Institutions. The top two priorities relate to the issues of accessing technologies and research expertise, which was not available within the firm, but was available at Higher Education Institutions. Financial gain ranks after ensuring equity in the enterprise's workforce. Added technological value, sustained technological innovation and human resource development thus rank

highly. Factors appearing at the lower end of the ranking in Figure 1 include the factors relating to direct industry gain such as tax rebates, company marketing and improved understanding amongst staff.

Associated with tax incentives should be a user-friendly Intellectual Property Rights legislation, developed and implemented by government to secure the necessary IPR when research is conducted by a research institution. Hand in hand with tax incentives and rebates goes the issue of third stream funding. The value of contract (i.e. third stream funding) flowing into Higher Education Institutions constitutes a measure of responsiveness, but it is important in the case of South Africa to keep in mind that, while increases in contract income indicate responsiveness, they must be managed so as not to erode the higher education research enterprise in the long term (DST, 2005:37). It is interesting to note that in the mentioned HSRC report, 90% of the industry respondents to the survey commented that direct outputs were *anticipated* from collaboration with Higher Education Institutions. Figure 2 below indicates the anticipated results.

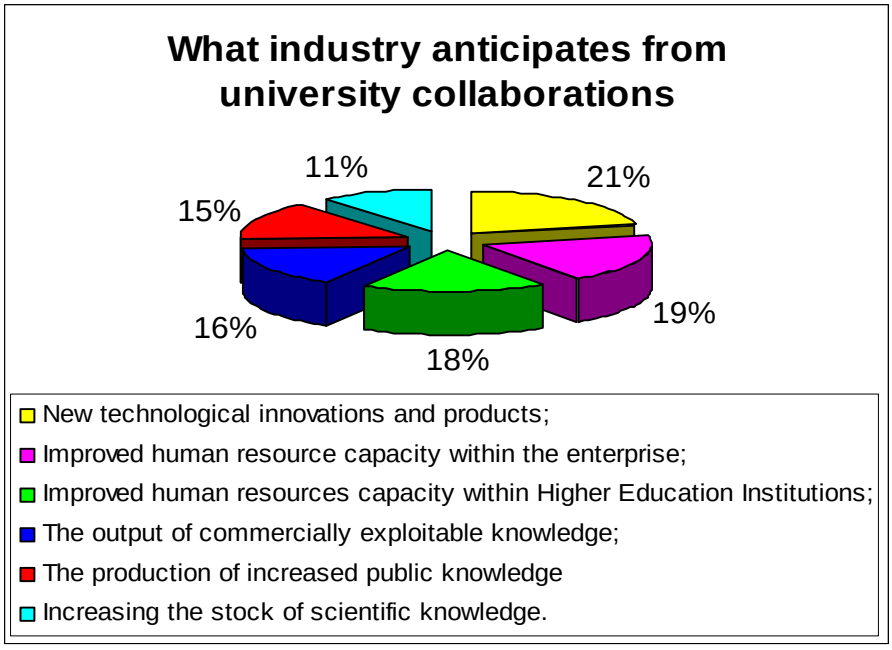


Figure 2: What industry anticipates from university collaborations (HSRC, 2003:116)

Marketing university research, however, is still no simple matter in South Africa. One reason is that funding is at stake. Leydesdorff & Etzkowitz (2001:4-5) reason that scientists, policy makers, and industrialists have to manoeuvre carefully in order to respect the subsidiarity between the different levels; it is important that they are able to use the knowledge base to change their roles, interactions, and positions.

Clark (1998:140) advises universities to build a 'diversified funding base' and to construct a 'portfolio of patrons to share rising costs', because the greater the number of income streams and the more diversified the funding, the less dependent universities will be on government subsidies.

'R&D is undergoing intense change due to rising costs, the spread of talent and markets, and the penetration of information technology, which is all influencing the location of research and how knowledge is shared (DST, 2005:50); and over the past fifteen years, the environment for research and innovation in South Africa has changed in several important ways, namely:

- 'Collaboration is much more common, reaching across disciplines, geographic distance, and between companies, academia and various types of research and technology organizations;
- Sharing of once-protected or *invisible* knowledge – through alliances, open source networks, or the Internet – is becoming more pervasive' (DST, 2005:50).

It is interesting to note that in their research in Europe, Liebeskind et al. (1996) discovered that companies who engage in joint research and publishing with academic institutions are more effective at sourcing new scientific knowledge than those who do not have joint activities. In short, being part of the social network is important (McMillan et al., 2000:3).

South African Higher Education Institutions wishing to raise the bar in terms of bettering the collaborative relationships with industry, need to focus on new possibilities for joint ventures, while exploiting new inventions as well as other R&D products and services. Doing so increases South Africa's national R&D assets as well as patenting and licensing opportunities with other spin-off's such as Science Parks. One such highly successful endeavor in South Africa worthy of mention is that of THE INNOVATION HUB[1] located between the UNIVERSITY OF PRETORIA[2], the NATIONAL RESEARCH FOUNDATION[3] and the COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH[4]. All collaborations, training, workshops and business endeavours are geared to advance knowledge transfer between stakeholders and commercialize as many products and services as possible.

Knowledge management is an enabling function, but the transfer of R&D knowledge between HEI's and industry requires a dedicated and dynamic team who will create, implement and maintain the knowledge transfer correctly, effectively and efficiently in order to promote technology commercialization. As mentioned previously this research dissertation is looking at the relationship between industry and universities in order to determine the gap between expectations and perceptions.

1.1.3 The Triple Helix Model

The Triple Helix relationship between universities, industry and government has been probed in depth for many years. The Triple Helix is a popular model for describing innovation systems. A Triple Helix system can be expected to exhibit all kinds of chaotic behavior such as *unintended consequences*, crises, niche formation, and self-organization, and for this reason the model is multi-structural and multi-functional (Leydesdorff & Etzkowitz, 2001:1, 9).

[1] http://www.theinnovationhub.co.za
[2] http://www.up.ac.za
[3] http://www.nrf.ac.za
[4] http://www.csir.co.za

Etzkowitz et al. (2000:314) wrote an article, *The future of the university and the university of the future*; in it they explain that the emergence of the entrepreneurial university is a response to the increasing importance of knowledge in national and regional innovation systems and the recognition that the university is a cost effective and creative inventor, as well as transfer agent of both knowledge and technology.

A question posed by Etzkowitz & Leydesdorff (2000:110) is the following: 'Can academia encompass a third mission of economic development in addition to research and teaching, especially if one considers the increased salience of knowledge and research to economic development.' Within universities there are 'interacting sub-dynamics which span transaction spaces and these institutional layers function mainly as a retention mechanism for economic wealth, archival knowledge and best practices respectively' (Van Lente & Rip, 1998).

Close university-industry collaboration will benefit the university in many ways, writes Lee (1996:857) and some of these benefits include the provision of the opportunity to make a visible impact on the local, regional, and state economy, to enhance revenue streams and increase training and employment opportunities for the university's students. A National System of Innovation also benefits from knowledge practitioners being located in multiple knowledge generating sites and institutions such as higher education institutions, government and civil society research organizations, as well as in private sector think tanks and laboratories (Mouton, 2000:358).

1.1.3.1 Government's perspective in the Triple Helix

The first component of the Triple Helix is government. Etzkowitz et al. (2000:314) mention that governments in virtually all parts of the world are focusing on the potential of the university as a resource to enhance innovation environments and create a regime of science-based economic development. Etzkowitz et al. (2000:320) mention that internal changes within academia can be strengthened and

diffused by government policy. They then go on to mention that there is a 'transition toward a mixed system of market forces and government incentives and that the interaction of government, industry and academia is *shifting*, from previous modes of *separation* or control, into a triple helix of overlapping, yet relatively autonomous spheres. The issue of overlapping and disbanding of relationships between the government, industry and academia offers countless research possibilities and in South Africa holds many possibilities for the expansion of collaborative agreements.

In South Africa, in particular, there is a great need to enhance research funding. In response to the increasing rates of knowledge production, dissemination and application, the shortening of product life cycles and the increasing competition for human resources, many countries are increasing their national investment in research and development (DST, 2005:28). So, the amount of government investment should be 'enough to signal an appropriate, comprehensive and sustainable strategy for a knowledge economy' states the DST (2005:28). At the same time one has to agree with Jacob et al. (2003:1558), who writes that 'the distinction between public and private is at best a grey one, with the state being a powerful influential actor in terms of its regulatory power over the university sector as a whole and its role as largest funder.'

Feller (1990:336), on the other hand, argues that the 'conventional tripartite distribution of roles of universities, firms and government as sponsors and performers of basic, applied and developmental research, represent a historic equilibrium that has evolved from an error-strewn search by each participating institution for a means to accomplish its specific objectives.' Each institution can assume the role of the other, Leydesdorff & Etzkowitz (2001:2) explain; 'under certain circumstances, the university can take the role of industry, helping to form new firms in incubator facilities. Government can take the role of industry, helping to support these new developments through funding programs and changes in the regulatory environment. Industry can take the role of the university in

developing and training and research, often at the same high level as universities.'

Changes in government policy, antitrust rulings, and tighter or looser environmental laws can also change a firm's economic time (Williams, 1998:175). Deregulation can encourage innovation and open a market to new competitors. Environmental protection policies can set high entry barriers for competitors and cause cycle time to slow down, but regulation also can encourage a uniform, freely available standard, speeding up economic time. Technology shocks, government policy changes, and revisions in corporate strategy do not work their change on a market independent of one another. Instead the cycle-shifting forces are often interlinked and not caused by one particular force alone, but by a combination or particular sequence of changes (Williams, 1998:175). The various aspects mentioned must be kept in mind by South African firms, because decisions made in government impact greatly in some instances on some industries and the effect cannot be ignored.

1.1.3.2 Universities' perspective in the Triple Helix

Etzkowitz et al. (2000:314-6, 320 and 329) see universities as a key element of the innovation system both as *human capital provider* and a *seed-bed of new firms,* but these authors stress that the entrepreneurial university requires an enhanced capability for intelligence, monitoring and negotiation with other institutional spheres, especially with industry and government. Internal changes within academia can be *strengthened* and *diffused* by government policy, while at the same time there is evidence of the growth of university spin-off firms in response to the pressure of commercializing the science base or of developing knowledge-based services for larger firms that sub-contract R&D activities.

Clark (1998:5, 7) writes extensively on universities and the necessity of organizational pathways of transformation. In this respect he explains that entrepreneurial universities are characterized by five elements, namely:

- A strengthened steering core, which is quicker, more flexible and more focussed to react to demands from its environment;
- An expanded development periphery in order to reach across their traditional boundaries and relate to the outside world;
- A diversified funding base and resources to change discretionary funds and widen their financial bases;
- A stimulated academic heartland where academic values are rooted in an entrepreneurial culture and all faculties are stimulated to react positively to change; and
- An integrated entrepreneurial work culture that embraces change and becomes the very base of the institution's identity.

Universities need to become quicker, more flexible, and especially more focused in reactions to expanding and changing demands, stresses Clark (1998:5, 103); 'they need a more organized way to refashion their programmatic capabilities,' and this includes collaborations with industry. What is important, however, is what Clark refers to as *the entrepreneurial response* and by this he means that universities must fashion a response from the possibilities, which arise from the interaction of organizational capabilities taking environmental limitations, openings and contexts into consideration. If universities are sharply conscious and continuously mindful of the need to 'construct departmental research as well as institutional niches in national and international domains,' this will require a flexible outlook and a variety of developmental trajectories to address industry and societal needs (Clark, 1998:124).

Etzkowitz et al. (2000:320) realise and acknowledge that there is a strong advocacy for universities to confine themselves to traditional academic-industrial relationships such as consultation, together with research and teaching as academic missions. These authors are of the opinion that in a knowledge-based society, 'the distance among institutional spheres is reduced' and this inevitably affects the content

and format for teaching and research. This brings these authors to comment that in addition to translating research into economic development through various forms of knowledge and technology transfer, the traditional teaching role is *reinterpreted* as the university assists in the modernization of low- and mid-tech firms, because technology too, contains embedded knowledge. Continuing their argument Etzkowitz et al. (2000:320), state that a *dual cognitive mode* has emerged in academic science as researchers focus both on achieving fundamental advances in knowledge and inventions that can be patented and marketed. Such academic institutions must assume a role in economic development through extensions of both their research and teaching missions. One must, however, keep in mind that, 'others view the entrepreneurial paradigm as a threat to the traditional integrity of the university' (Etzkowitz et al., 2000:313-314).

In Clark's book entitled, *Creating entrepreneurial universities* (1998:4) he writes that 'an entrepreneurial university, on its own, actively seeks to innovate in how it goes about its business. It seeks to work out a substantial shift in organizational character so as to arrive at a more promising posture for the future.' Thus entrepreneurship can be seen as both process and outcome. Based on this statement it can be noted that the contemporary university is an amalgam of teaching and research, applied and basic, entrepreneurial and scholastic interests. These elements exist in a *creative tension* that periodically comes into conflict, but 'the model of the university centre as a *vehicle for technology transfer* has become organizationally and institutionally more complex, acting as a conduit through which knowledge exchange and exploitation is made more effective. Firms, universities and governments who, individually and collectively, engage in bottom-up planning, road mapping and foresight exercises are more likely to reap future rewards than their peers' (Etzkowitz et al., 2000:326).

At the same time close university-industry collaborations will benefit the university in many ways such as providing the opportunity to make a visible impact on the local, regional, and state economy,

enhancing its revenue streams and increasing training and employment opportunities for students (Lee, 1996:844, 857). In principle Henderson et al. (1998:119) agree that, 'universities are dedicated to the widespread dissemination of the results of their research,' but at the same time universities also find themselves 'under increasing pressure to translate the results of their work into privately appropriable knowledge.' This phenomenon of the changing role of universities as creators and sources of innovative technology is worth exploring both as a public good and as a critical stakeholder in the process of robust and pro-active technology commercialization.

Lee (1996:844) mentions that institutions of higher education are under pressure to increase the flow of new knowledge, know-how, and people to industry and society at large and this is why policymakers are advised to focus R&D funding strategy in a way that harnesses research for economic development generally and industrial competitiveness in particular. It is important to Lee (1996:844) that Higher Education Institutions 'tap into tacit to tacit (hidden), tacit to explicit, explicit to tacit and explicit to explicit (obvious) reserves of knowledge, and that they market this knowledge to the benefit of industries, the economy in general, and society as a whole.' Wolff & Gibson (1997:2) hold the view that technology-based entrepreneurship will increasingly demand organizational flexibility and compression of time-to-market in a way that integrates and that this will cut across institutions, suppliers, and industry sectors.

It is important to keep in mind, though, that industry provides a new window of opportunity for research and support according to Lee (1996:849) and that the recognition for pre-commercialization research is more accepted today, because universities are expected to be accountable to society economically. Veblen's opinion (in Feller, 1990:335), is that 'work that has a commercial value does not belong in the university' but the opposite is currently the case; Feller states that 'the current stance is an aggressive reach into the research laboratory where universities actively search for

commercializable new applications of technology and then seek to develop the product or process, with an associated business entity, through early stage commercialization.' Commercialization and academic contributions to scientific and technological knowledge may thus be joint products of research.

One would be justified in describing academic science in South Africa, according to Mouton (2000:462) as 'an isolationist system.' One reason for the isolation is apartheid. The word *apartheid* refers to a political dispensation in which racial segregation was the norm in this country and has resulted in severe barriers to collaborate nationally and internationally (due to sanctions) and many barriers of knowledge transfer may still be in place. These barriers need to be addressed mindful of what Lee (1995:857) writes: 'a close university-industry collaboration will benefit the university in many ways, such as providing the opportunity to make a visible impact on the local, regional, and state economy, enhancing its revenue streams and increasing training and employment opportunities for students.'

1.1.3.3 Industry's perspective in the Triple Helix

It is important to keep in mind that industry provides a new window of opportunity for research and support (Lee, 1996:849) and that the recognition for pre-commercialization research is more accepted today, because universities are expected to be accountable to society economically. One problematic area according to Feller (1990:345) is the following: 'if a university's motivation for entering into R&D arrangements is scarce financial resources, an industry's motivation is scarce technical knowledge, moderated by a desire to limit risky investments. Industry is therefore likely to seek out research contracts with selected universities and scientists of acknowledge excellence.'

According to Katz & Martin (1997), the following six factors motivate industry research collaboration:

- Escalating costs of conducting fundamental science;

- The decrease in the cost of travel and communication, which leads to increased mobility among scientists;
- As a social institution, science depends on interaction and networks to grow;
- The increased need for specialization in certain fields such as high-energy physics;
- The growing importance of interdisciplinary fields such as biotechnology;
- Political factors, such as the growing integration of science in Western Europe, that promotes cross-national collaboration.

Collaborative partnerships mean different things to different stakeholders and from Kruss (2002) it is clear that these definitions include terms like *collaborative relationship* and *professional relationship* implying that these are relationships based on clearly and mutually defined needs and benefits, which should involve equal contributions by both parties and team members should work in a complementary manner (HSRC, 2003:26, 27). An ideal vision of the role of research partnerships between higher education and industry in a rapidly globalizing knowledge economy is becoming more prevalent; however, there is a great deal of dissonance between this vision and the realities of research, innovation and development. This is especially the case in the South African context, which is characterized by fragmentation, inequalities and unevenness (HSRC, 2003:ix).

The difference between research joint ventures and partnerships is not always clear, but Revilla et al. (2005:1308) using the 1996 definition of the INTERNATIONAL COUNCIL ON COMPETITIVENESS writes that a partnerships can be defined as '*cooperative arrangements* engaging companies, universities and government agencies and laboratories in various combinations to *pool resources* in pursuit of a shared R&D objective.'

Perlas (2002) suggests that in understanding the new social landscape, the concept of *three-folding* is helpful. He argues that 'the forces, capacities and resources to change the world are clustered in the hands of business, government and global civil society' and in his opinion a healthy society is one where these three realms mutually recognise and support each other and develop their initiatives with awareness of their potential impact on each other.

Organizations characterized by pro-active leadership provide a conducive environment for managing knowledge as a critical resource. To a certain extent this point is connected to transformative governance, which Cloete & Bunting (2000:52) write, is characterized by an *expanded leadership core* with a *shared transformation discourse,* or future plan of direction. Here the style of leadership is *directive*, but balanced by *consultation* and participation, and there is a good working relationship (i.e. supportive and critical) between management and subordinates at all levels.

At the most basic level such an environment is conducive to knowledge creation and the protection and exploitation of this critical resource within the organization. This research dissertation looks at university/industry relationships in order to determine the gap between expectations and perceptions and what drives these collaborations.

1.1.4 The Research-to-Innovation Value Chain

When approached by an industry partner, a collaborative relationship commences between such an industry partner and the contracted university. Amadi-Echendu (2005:1) describes these linkages by using the concept of a 'Research-to-Innovation Value Chain' (see text box below), where the goal is to transfer knowledge from research into innovative outcomes.

The Research-to-Innovation Value Chain consists of the following stages:

- The first stage is Basic Research in which new knowledge is generated and such knowledge forms a bridge to the international scientific environment; Hughes (2003:12) adds that basic research is the pacemaker of technological progress;
- The second stage is Applied Research, where the idea is verified and tested extensively. Stokes (1997:3) adds that applied research and development will convert discoveries into useful applications;
- The third stage is Product or Service Development;
- The fourth stage is the Commercialization of the knowledge in the form of products or services.

1.1.5 The Technology Colony Concept

South Africa's science and technology landscape has been described as a *technology colony* by Oerlemans, Buys, Pretorius & Rooks (2001). To expound on what this concept means consideration must be given to De Wet (2001), who states that one characteristic of a *technology colony* is that research and development activities carried out within universities and other state-funded institutions, tend not to translate into innovative outcomes and have a less significant impact on economic development. The implication, therefore, is that an almost insignificant flow of knowledge is transferred from the local R&D community to the local industrial sector, and much of this industrial business activity is done under foreign licence. The point De Wet (2001:2) makes is that countries such as ours, characterised as *technology colonies,* have to arrive at the point where they want to have a larger share in the determination of their economic future, and in the words of Lundvall (in Dozi et al., 1988:360) 'establish themselves as technological leaders, generally or in specific technologies.'

There are two types of technology colony (De Wet, 2001:2, 3):

(a) The first type of technology colony derives its competitive advantage mainly from human resource productivity;

(b) The second type of technology colony, such as South Africa, is a country, which is *rich in natural resources* such *as* mining and agriculture, and these resources form nodes that determine the development of the country's infrastructure and communication networks and also enable the country to retain power in terms of the colony's financial and related industrial sectors.

In order to better understand what characterises technology colonies, De Wet (2001:2) describes the general features of a technology colony as follows:

- Manufacturing and trade-in-final products are the predominant business activity;
- R&D is a small component, mostly found in universities;
- There is a large flow of technology from the developed world into the colony, in the form of licensed product designs, processes, sub-assemblies and final products; and
- There is an almost insignificant flow of technology from the local R&D community to the local industrial sector.

Being a technology colony is not a fate to be suffered; however, it should rather be seen as an opportunity to be managed. De Wet, (2001:1, 6) motivates this statement by encouraging firms to become 'skilled at creating the best possible growth trajectories for their economies.' Lundvall (in Dozi et al., 1988:364) emphasizes that despite the fact that 'universities and other public institutions involved in the production of science are important parts of the system of innovation,' university/industry relationships in a *technology colony* suffer to a greater or lesser extent due to the fact that many local

businesses operate as representatives of larger foreign partners, and this implies that *imitation* or *improvement* dominates technological innovation (Oerlemans, Buys, Pretorius & Rooks, 2001). This situation can also act as a barrier for industry partners with overseas affiliations to engage local universities in R&D collaborations, because in most instances the R&D function is located in the country where the head office resides. The result is that inventions are commercialized outside of South Africa. Oerlemans et al. (2001) also suspect that the *technology colony* position arises partly because of weaknesses in the relationship between industry and universities in terms of knowledge transfer and this is the critical issue to be addressed in this research project, hopefully providing ample actionable information in order to make knowledge transfer more effective.

1.2 The South African Landscape of Science & Technology

1.2.1 Science & Technology Policies in South Africa

Before commencing with the specifics pertaining to the South African context, some general comments will be made on science *per se*. Hassan (2002:1, 2) states that 'science alone cannot save Africa, but Africa without science cannot be saved either.' Africa is a continent with 53 nations according to Hassan but has only nine merit-based science academies, and as a result Hassan holds the debatable opinion that the continent may lack the technical capacity to initiate and sustain its own development process.

Narin et al. (1997:317) define *public science* as 'scientific research that is performed in academic and governmental research institutions and supported by governmental and charitable agencies.' These authors are of the opinion that public science is a driving force behind high technology and economic growth. What is hard to determine however, is the magnitude and the direction of that force. The economic impact of science has, of course, long been a motivation for the government's support of academic research.

The science and technology landscape in South Africa has, as its departure point, the SOUTH AFRICAN DEPARTMENT OF SCIENCE & TECHNOLOGY'S national mandate, which aims to encourage, empower and fund initiatives (such as the critical linkages between Higher Education Institutions and industry), in the drive to make South Africa an innovative country. The timeliness and relevance of this project is self-evident from this perspective.

> 'Science creates conditions for economic and national development, and raises the prestige of a country in the modern world. The most important goal of a science education technology policy is to achieve results, which in the near future, will support the process of social and economic transformation, and in the long run will ensure economic growth and social development of the country, by making the most of resources set aside for scientific research and development. To reach this goal, it will be essential to link science effectively with other areas of social and economic activity, and with education in particular' (White Paper on Science & Technology, 1996: Chapter 3).

This key focus area filters down from the South African Government and becomes a mandate of the entire higher education sector. If all of science requires a refinement of our everyday thinking, then universities in South Africa need to refine their thinking about how research is marketed to industry partners. South Africa has a strong and vibrant science and technology base, but continual refinement comes to the fore in how this country finds innovative ways to exploit new products and services, technologies, processes and methods in commercially viable ways. This implies a need for a far greater transfer of research and development knowledge from Higher Education Institutions to industry partners.

Pityana (2005:8) writes that universities need to enhance a learning environment, to advance research and to create an environment

conducive to scientific enquiry, intellectual inquisitiveness, and to social development. Sound infrastructure, explicit and tacit knowledge resources plus a strong R&D capacity make Higher Education Institutions the ideal platform for the creation of high-technology industries and incubator opportunities, which in turn stimulates economic growth and powers a variety of employment opportunities. Industry on the other hand can exploit R&D knowledge through a variety of collaborative and joint ventures in which products and services can be commercialized. Higher Education Institutions can be seen as a type of *tour guide* toward knowledge attainment, or, as Guenther (2001:54) puts it a 'pathfinder to information and a caretaker of human knowledge.' This implies that Higher Education Institutions need to be able to stay abreast of current information; complex application environments and they must have the ability to exploit sources and resources in a manner that benefits industry and society as a whole.

Higher Education Institutions are under tremendous pressure to stay abreast of technological advances, create new knowledge and educate, but at the same time they find themselves in an advantageous position to partner with industry and the business sector to take creative ideas with entrepreneurial potential through the stages mentioned above. In this Research-to-Innovation Value Chain Higher Education Institutions transform R&D into *actionable knowledge*. This knowledge according to *Industrial Innovation in SA* (2003:3) must then be transferred and communicated in such a way that:

- The educational benefits and learning opportunities are distinct and can be applied in practice;
- Intellectual property is protected;
- Strong citation index values become evident as a result of the scientific papers published on the issues;
- Patenting is encouraged and sound in terms of legislation;

- Licensing proceeds in the most efficient manner; and so that
- The process ensures a viable, fiscally sustainable product/service, which is eventually commercialized.

The SOUTH AFRICAN NATIONAL RESEARCH AND DEVELOPMENT STRATEGY (NRDS, 2002) was published as a key enabler of economic growth by government with the realization that science is a highly globalized activity in terms of *reach* and *scope.* NRDS (2002:17, 37) rests on *three pillars* namely:

(a) Enhanced innovation;

(b) Science, engineering and technology (SET), human resources and transformation; and

(c) Creating an effective government, science and technology system and infrastructure, to ensure that international best practice with respect to government funding of science and technology, namely the well-articulated functions of basic research (knowledge generation), innovation (new businesses, products and services) and venture capital, is observed.

In order to achieve mastery of technological change in our economy and society all relevant institutions, the private sector, research organizations, venture capital and universities will be mobilized to deliver innovation through the technology missions by creating and synergizing innovation activities linked to universities and research organizations that can strengthen initiatives for the commercialization of intellectual property (NRDS, 2002:23, 39-40).

1.2.2 South Africa's Research and Development Landscape

The general scenario in South African organizations, however, is that 'good technologies are lost or not commercialized, because of a lack of innovation resources, and many South African organizations currently have little opportunity or resources for quantum innovation' (NRDS, 2002:41).

Some of the desired outcomes of the technology and innovation mission are the enhanced adoption of imported know-how, the increased rate of innovation and improvement, and the incubation and establishment of new enterprises, but also South African-controlled global intellectual property licenses, and key technology platforms, which will focus on knowledge intensive new industries (NRDS, 2002:42). This statement provides substantiation for Liebeskind et al. (in McMillan *et al.*, 2000:3) to write that companies which engage in joint research and publishing with academic institutions are more effective at sourcing new scientific knowledge, than those companies which do not have joint activities.

The financial instruments which provide funding opportunities for these initiatives, mentioned in the NRDS document (2002:39), include, the 'Innovation Fund, THRIP, Focus Area Grants (via the NRF), SPII and PII and programs tasked with technology diffusion and transfer including Tsumisano, GODISA and NAMAC.'

The *Centre for Science, Technology & Innovation Indicators* (CeSTII) Report[5] for 2003/4 on R&D Expenditure (Kahn, 2005), provides recent figures available in South Africa on the status of R&D in the government sector, industry sector and the higher education sector. Based on the OECD Frascati Manual (2002), South African R&D performers are divided into five sectors (Kahn, 2005:3):

(1) THE BUSINESS ENTERPRISE SECTOR, which includes large, medium and small enterprises as well as state-owned companies;

(2) THE GOVERNMENT SECTOR, which includes all government departments with an R&D component, government research institutions and museums. Within the SA government sector there are state-owned corporations such as Denel, Eskom, NECSA, Telkom, Transnet and Safcol (NRDS, 2002:61);

[5] The full report can be downloaded from http://www.hsrc.ac.za/RnDSurvey.

(3) THE HIGHER EDUCATION SECTOR, which includes all South African Universities and Universities of Technology;

(4) THE NOT-FOR-PROFIT SECTOR, which includes all non-governmental and other organizations formally registered as not-for-profit institutions; and

(5) THE SCIENCE COUNCIL SECTOR, which comprises the following nine South African Science Councils.

- Mintek: The Council for Minerals Technology
- AISA: The Africa Institute of South Africa
- CGS: The Council for Geoscience;
- CSIR: The Council for Scientific & Industrial Research;
- SABS: The South African Bureau of Standards;
- MRC: The Medical Research Council;
- ARC: The Agricultural Research Council
- NRF: The National Research Foundation, and
- HSRC: The Human Sciences Research Council.

The Science Councils in South Africa, during 2003/4-book year accounted for R1 745 493 million worth of R&D expenditure (Kahn, 2005:55).

1.2.2.1 Economic Indicators

Before commencing with the source of R&D funds in South Africa as well as the formal R&D expenditure figures, the economic indicators for the year 2003/4 are provided (Kahn, 2005:12), so that overall expenditure can be evaluated. These indicators cover the core R&D indicators required for endorsement by the OECD.

Indicator	Value
GDP – Current prices in millions of Rand	1 251 469
GDP – 2000 Constant Prices in millions of Rands	1 008 649
Purchasing power purity (Rands per US$)	2.55
Value added in industry per million of Rands	897 316 576
Implicit GDP Price Index (base year 2000-1.00)	1.241
National Population (thousands)	45 026
Labor Force (non-primary formal sector – thousands)	6448

Table 2: South African Economic Indicators 2003/4 (Kahn, 2005:12)

1.2.2.2 The source of R&D funds

The source of R&D funds for business enterprises, government and higher education according to Kahn (2005:15) include funds received from government, other businesses, higher education, domestic and foreign funds as well as organization funds.

Funder	R000s
Business Enterprises	R5 591 325
Government	R 465 367
Higher Education	R2 071 351

Table 3: R&D Sources of Funds 2003/4 (Kahn, 2005:15).

1.2.2.3 R&D Expenditure 2003/4

The figures below summarize in-house R&D expenditure in the sectors of government, business and higher education (i.e. the Triple Helix partners where the focus of this research dissertation lies, but also includes those of the Science Councils and Not-for-Profit organizations in South Africa).

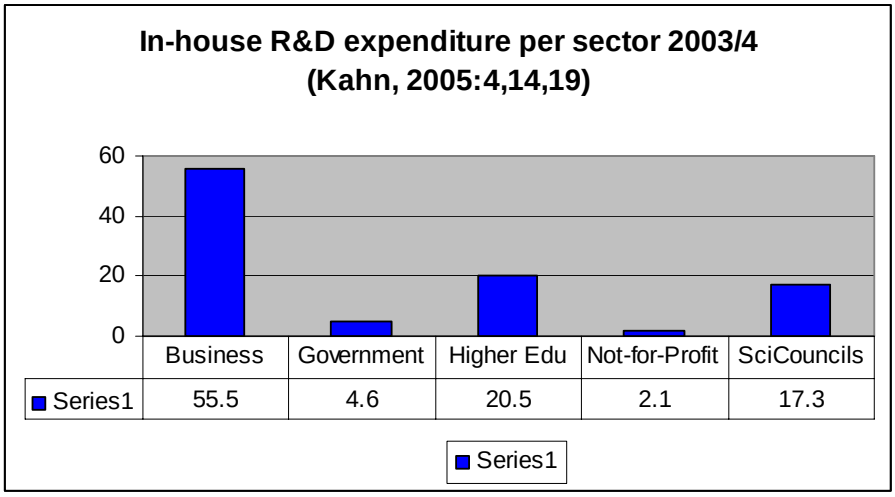


Figure 3: In-house R&D expenditure per sector 2003/4 [1] (Kahn 2005:19) [Indicated in percentage]

Another way of indicating the In-house R&D expenditure per sector for the period 2003/4 is portrayed below in Figure 4.

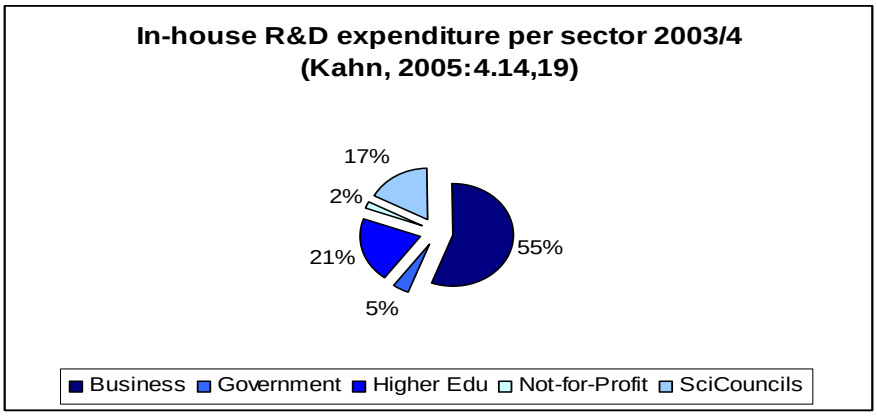


Figure 4: Percentage of In-house R&D Expenditure per sector 2003/4 [2] (Kahn, 2005:4, 14 and 19)

What can be seen is that the business sector contributes the major part of R&D activity in the South African economy; devoting up to three times more time to R&D than do universities (because of their teaching and administrative roles), but no mention is made of the time relation to expenditure.

It is evident from the figure above that the business sector is the largest R&D performer. Kahn (2005:19) comments that the size,

dynamic nature and diverse character of the business sector contribute to the ongoing challenge to ensure greater coverage while ensuring no double counting or significant under-counting.

Universities have to become more proactive about leveraging knowledge resources to uncover useful and pertinent information, which can be advantageous not only to themselves, but also to industry and the South African government.

1.2.2.4 Headcount of Personnel involved in R&D

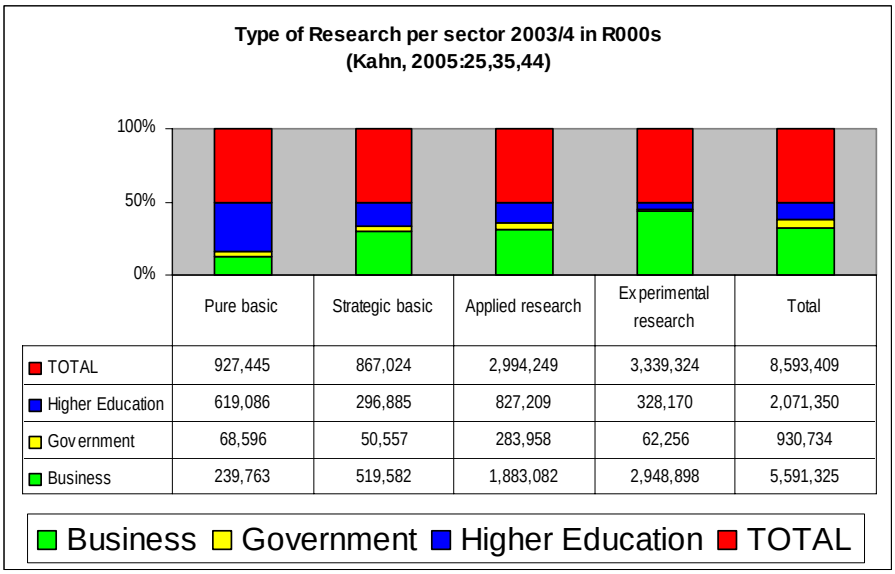
The relevant figures of the numbers of personnel who are involved in R&D endeavors in South Africa appear in Table 4 below. In the period 2003/4, 22760 researchers and 17844 R&D personnel supported the country's R&D effort. These figures exclude post-graduate students. Except for the headcount figures, no indication is given in this report about what the actual involvement and time contribution of researchers and support personnel is between industry and universities, but it would be interesting to know.

Sector	Researchers	Technicians directly supporting R&D	Other personnel directly supporting R&D	Total	%
Business enterprise	5058	3430	3120	11608	28.6
Government	929	322	1032	2283	5.6
Higher Education	14054	2594	2728	19377	47.7
Science Councils	2414	1612	2496	6522	16.1
Not-for-Profit	305	235	275	815	2.0
Grand Total	22760	8193	9651	40605	100.0

Table 4: Headcount of personnel involved in R&D 2003/4 (Kahn, 2005:5)

1.2.2.5 Type of Research

Figure 5 below indicates what business/industry, government and higher education have contributed to the various types of research in the period 2003/4.



	Pure basic	Strategic basic	Applied research	Experimental research	Total
TOTAL	927,445	867,024	2,994,249	3,339,324	8,593,409
Higher Education	619,086	296,885	827,209	328,170	2,071,350
Government	68,596	50,557	283,958	62,256	930,734
Business	239,763	519,582	1,883,082	2,948,898	5,591,325

Figure 5: Type of research per sector 2003/4 (Kahn, 2005:25, 35 and 44)
[Figures indicated in R000's]

It is noteworthy that the business sector seems to be focused on experimental development (52.7%), and applied research (Kahn, 2005:25, 40-41). In comparison, GERD research (i.e. expenditure for the research undertaken by government), 61% of R&D is spent on applied research with only 14% spent on pure basic research. Kahn's comments (2005:35, 38) are that 86.9% of government R&D expenditure was funded by government itself, through internal resources, national and provincial government as well as science councils and agency funding.

'The total government in-house expenditure was R465.3 million in the 2003/4 survey, or 4.6% of the gross national expenditure on R&D:

- In the government sector 40,8% of R&D expenditure went to national departments;

- 33.3% to research institutes;
- 18.7% to provincial departments; and
- 7.2% to museums' (Kahn, 2005:31).

Finally, the Higher Education Sector spent the largest portion of its R&D monies on basic research (44.2%) of which 29.9% was devoted to pure basic research and 14.3% to strategic basic research; applied research (39.9%) comprised the second largest component of R&D expenditure within the sector, followed by experimental development (15.8%). The largest portion of funding for Higher Education R&D was derived from general university funds (38.6%) (Kahn, 2005:44).

1.2.2.6 Socio-Economic Objectives

For the purposes of this research dissertation, which is focused on the drivers of knowledge transfer between universities and industry, the following table is important. This HSRC table looks at Business Enterprises R&D (BERD) by Socio-Economic Objective and clearly indicates what industry and business firms in South Africa consider important enough to fund projects in these critical areas.

Socio-Economic Objective	R 000s	%
Defense	849,574	15.2
Economic development	3,935,136	70.4
Society	502,865	9.0
Environment	151,043	2.7
Advancement of knowledge	152,708	2.7
Total	5,592,325	100.0

Table 5: Business Enterprise R&D by socio-economic objective 2003/4 (Kahn, 2005:27)

These figures indicate that research in the business community is evidenced by three strong socio-economic objectives and they are (a) defense, (b) manufacturing (under economic development) and (c)

society (which include health, education and social development as well as community services). This should alert universities to focus their R&D efforts to a greater extent on these fields.

1.2.3 Universities as a source of R&D knowledge in the knowledge arena

The global village as we know it today is 'a jungle of human confusion,' posit Komives & Petersen (1997:83) and in this jungle, information users such as industry firms, need to assimilate a body of knowledge that is expanding by the minute; they require guides, pathfinders and resources that will assist them in their endeavours. Many individuals and organizations are grappling with an information deluge and are apprehensive about the ever-widening gap between what we know and understand and what we *think* we should know and understand. The fact that technology delivery mechanisms are becoming more advanced, makes processing of the glut of information extremely complex.

In this complex environment, academia needs to transfer knowledge to industry and industry needs to transfer knowledge back to universities. Pandor (in Monare, 2006:6, 7) has stated that higher education has a crucial role to play in achieving the growth target of 6% communicated in the ACCELERATED AND SHARED GROWTH INITIATIVE (AsgiSA) of government. One method is via the commercialization of innovations.

Innovation has always been a defining feature of human society according to Simpson (2002:51) and never more so than today, when the creation and commercialization of new knowledge provides the vital underpinnings of the emergent knowledge society. Innovations, especially if they are to be sustained over time, are an extraordinarily complex, even chaotic, process. According to Drucker (1985) the process of innovation involves endowing *existing* resources with new wealth-producing capacity and this process may involve the following:

- A new application of an existing technology,

- A new product, or service innovation;
- A new way, or place of doing business.

Whatever form it takes, reiterates Amit et al. (1990:1233), 'there is a substantial amount of ex-ante uncertainty about the wealth-producing capacity of the newly created capital, due to the feasibility and market acceptance of the innovation, and the pace at which imitation will erode the extra-ordinary profit from the innovation.' The tendency is that innovations will carry a high level of risk until proven and sufficiently diffused into society. The time lag between the creation of a new scientific concept and its general application, however, is usually measured in decades (Giamatti, 1982:1278); this being the case, the challenge in a developing country and technology colony such as South Africa lies in continuously building intellectual capital and expanding on a country's existing resources.

1.3 The Research Strategy in understanding knowledge transfer drivers between universities and industry in R&D collaborations

Is it not true that today, all over the world, relationships of many sorts blossom between university and industry, asks Kenny (1986:73). South Africa is no exception. In many instances strong ties do exist between South African universities and industry partners in a multiplicity of research fields, however, in developing countries, Kenny (1986:74) has observed that 'most universities direct participation in private industry is beyond the pale of acceptability, and for many the cost of a patent office with its ancillary staff is not warranted because of the limited number of inventions.' Very few South African universities have a Patent Office – this function is usually incorporated elsewhere, for example in the Registrar's Office.

Speaking from a USA perspective, Kenny (1986:79) mentions that the positive aspects of university-industry involvement are:

- University technology might help to revitalise the economy;

- The income generated could help support research, which may come under increasing financial pressure due to possible government cutbacks; and
- The licensing of patents and ownership of equity in new companies might secure substantial financial return.

In some cases all these suppositions become evident to a greater or lesser extent, but such definite benefits are not evident yet in South Africa. Focussing for the moment to the opposite pole namely the negative aspects of university-industry involvement, Kenny (1986:79) mentions the following aspects:

- The potential of inequality of faculty access to university assistance;
- Official university involvement might encourage researchers to divert time and energy away from academic pursuits;
- Even the appearance of conflicts of interests would harm the university and its image;
- Conflicts could arise regarding the allocation of space and resources due to the perception that commercially successful professors are favoured;
- The improper use of the university's name could cause problems; and
- A variety of ethical and public interest questions might arise.

These points are certainly a universal problem; however, it would be prudent to heed Kenny's warning (1986:80) that universities that seek a legitimate return from the ideas and inventions of their faculties must be careful not to lose their academic souls. If one questions the position of the university as an institution in society one should recognise that the university is not as detached and impartial as we would like it to be. We all become dependent on the sources of

funding, and funding agencies can exert a variety of pressures to influence our behaviour. There is a blurring of the distinction between the university and the marketplace the problem comes in that professors cannot be expected to be neutral when they are businessmen. The solution according to Kenny (1986:89) lies in the creation of new university arrangements in which professors with marketable skills are permitted to increasingly devote more time and effort to profit-making activities and those that choose pure academic pursuits should be allowed to plough their energies into that.

Concluding this point and moving on to the main focus of this research dissertation, namely on the drivers of knowledge transfer between universities and industry firms, the specific drivers to be examined are listed below:

1) The perception that knowledge is a valuable resource;

2) The emphasis on getting a return-on-investment in research;

3) The need to close the knowledge gap;

4) The need to extract appropriate knowledge at the right time to make critical decisions;

5) International trade;

6) The need to protect intellectual property such as patents and trademarks;

7) War, terrorism and natural disasters;

8) Geographic proximity between the knowledge source and recipient;

9) The need to protect knowledge for competitive advantage (Cummings & Teng, 2003:54).

1.4 The structure of the Research Dissertation

Chapter 1: Introduction & Background

This chapter introduces the research environment by providing a brief overview of the National System of Innovation, the landscape of science and technology in South Africa as well as the interface between universities and industry partners in terms of R&D collaborations. This chapter expounds on the Triple Helix model, the Research-to-Innovation Value Chain and explains what is meant by a technology colony.

Chapter 2: Literature Review

This chapter provides a synthesized literature review, focusing on recent theories and models that portray the current mode of thinking on the topic of knowledge transfer, particularly between universities and industry firms. This literature study includes a review of books, journal articles, Internet sources and newspapers, which together form the published information in the field. Particular attention will be given to the drivers of knowledge transfer in this interface between universities and industry.

Chapter 3: Empirical Research Design & Methodology

This chapter motivates the objectives and rationale for the research, it provides information on the design for data collection, and explains the progressive work plan employed in order to reach specific research objectives.

Chapter 4: Data Collection and Preliminary Findings

This chapter provides the preliminary articulation of the respondent's feedback regarding the drivers of knowledge transfer. The questionnaire was included in a RESEARCH MARKETING & TECHNOLOGY COMMERCIALIZATION SURVEY, which was the instrument used to collect the data. The significance of the findings are then discussed in this chapter.

Chapter 5: Analysis & Concluding Remarks

This chapter contains formal descriptive statistical analysis of respondent data including the research limitations. Some areas of future research are suggested following concluding remarks based on research findings.

Bibliography & Appendices

The bibliography will include all sources cited in the text. The one appendix is the last portion (Section IV) of the SOUTH AFRICAN RESEARCH MARKETING & TECHNOLOGY COMMERCIALIZATION SURVEY, which applies for the purposes of this research dissertation.

CHAPTER TWO

LITERATURE REVIEW

One critical issue evident in the RESEARCH-TO-INNOVATION VALUE CHAIN concerns the drivers of knowledge transfer between participating organizations. For example, understanding what drives industry to engage universities in R&D projects is important in terms of future positioning and negotiations regarding sustainable long-term collaborations.

The theoretical underpinnings of the drivers of knowledge transfer will be explored and a broad perspective of the recursive themes embodied in current literature will be teased out in this chapter. Mouton (2001:87) refers to the importance of reviewing 'a body of accumulated scholarship' and this includes a whole 'range of research products,' which, when synthesized, will present various perspectives, theories (personal, grounded or established) and clues to research avenues to follow. The interpretation and critical evaluation of research findings is done in an effort to ascertain what the significance and bearing of past research has on the South African R&D context.

This chapter commences with the role of innovation in knowledge transfer, and from there will proceed to a general overview of what literature infers about the drivers of knowledge transfer, then concludes with a discussion of each individual driver of knowledge transfer, with pertinent references to literature on that specific driver.

2.1 Literature Review on Knowledge Transfer Mechanisms

Dixon (2000) theorizes that there are five knowledge transfer forms within organizations, namely:

- Serial Transfer (i.e. frequent, non-routine tasks including explicit and tacit knowledge);
- Near Transfer (i.e. frequent and routine tasks using explicit knowledge);
- Far Transfer (i.e. tacit knowledge transferred socially; frequent and non-routine);
- Strategic Transfer (i.e. once-off projects, where tacit and explicit knowledge is shared among managers to complete a task); and
- Expert Transfer (i.e. generic and explicit knowledge is transferred from an expert source inside/outside to solve problems).

Karlsen & Gottschalk (2003:112) also evaluated the 'serial, near, far, strategic and expert knowledge transfer mechanisms' in their empirical research. They agree with Dixon (2000) and concur that in terms of successful knowledge transfer, it is the responsibility of management to allocate the appropriate mechanisms to create and share common knowledge i.e. the knowledge that employees obtain from doing the organization's tasks (see Glossary for more details).

Hislop (2003:160) refers to three mechanisms of knowledge integration and transfer, namely:

- Intensive team-based interaction;
- Formal education; and
- The dissemination and utilization of formal documentation.

Nahapiet & Ghoshal (1998) mention that the acceleration of knowledge transfer is affected by:

- The opportunity for knowledge transfer and exchange;

- The expectation that it will be worthwhile to do so for both parties; and
- Both parties being motivated to pursue knowledge transfer.

Another driver of knowledge transfer mentioned by Von Krogh et al. (2001) is the necessity of having *concrete learning targets* in which both sender and receiver of knowledge can assess the value and applicability of knowledge as well as the potential loss or gain thereof. Revilla et al. (2005:1310) comment that the manner in which knowledge is *packaged and dispatched,* has the potential to either enhance or to inhibit the receiver, to act appropriately or to assist him/her to make sound decisions.

Knowledge, being a valuable resource, needs to be managed and transferred effectively and efficiently, but knowledge transfer is a mechanism to be used selectively, stress Von Krogh et al. (2001:425), because not everybody in the company needs to know everything at all times. This implies that employees will function on a need-to-know-basis in terms of receiving information. Related to knowledge transfer is the process by which transfer is leveraged. In the opinion of Von Krogh et al. (2001:425) the following conditions must be satisfied for efficient and effective knowledge transfer:

- The parties (i.e. industry firms and universities) must be aware of the opportunity to exchange the knowledge;
- Both parties must expect the knowledge transfer to be worthwhile;
- The parties must be motivated to pursue the knowledge transfer – they must be interested in applying the knowledge transferred into their own activities to realise the benefits of the transfer;
- The next step covers packaging and dispatching of knowledge in such a way as to enhance the receiver's potential to act;
- In the last step the transferred knowledge is integrated with the local knowledge.

Within knowledge domains, Szulanski (2000:10) points out that 'knowledge transfer is seen as a process in which an organization recreates and maintains a complex causally ambiguous set of routines in a new setting' and it is therefore important to realise that 'knowledge domains are starting points, rather than end states' (Von Krogh et al., 2001:426-7) and that knowledge domains will change in order to reach a strategic goal, for example of innovating, enhancing efficiency, and better managing risk. If knowledge is viewed as a valuable resource in these knowledge domains the core processes of creation and transfer will dominate the evolution of these domains. Firms are therefore advised to examine activities and spending patterns in various functional areas throughout the firm in order to identify the level of activity on knowledge creation and transfer. Von Krogh et al. (2001:426-7) recommend looking for things such as technology investments, profiles of new hires, job-rotation and turnover of employees, training budgets, managerial career patterns, partnerships with firms and other organizations, collaborations across functions, departments, countries and business units.

Cummings & Teng (2003:54) identify nine successful knowledge transfer variables, namely,

- Articulability
- Embeddedness
- Physical distance
- Knowledge distance
- Norm distance
- Learning culture
- Project priority
- Organizational distance
- Transfer activities and

- Transfer success.

In their study Cummings & Teng (2003:54) incorporate the variables into four contexts.

The Knowledge Context: • Embeddedness • Articulability	The Relational Context: • Organizational Distance • Physical Distance • Knowledge Distance • Norm Distance
The Recipient Context: • The Project Priority • The Learning Culture	The Activity Contest: • The Transfer Mechanism

Table 6: Knowledge Contexts (Cummings & Teng, 2003:54)

It is important to remember that no one driver dominates over the others and no set of drivers can be attributed across-the-board to a single industry. The factors depend on the specific challenges under consideration, as well as the talent, market, and costs of research associated with that challenge (DST, 2005:57).

Global research and innovation networks are increasingly common forms of knowledge creation in both open science, engineering, and in industrial development. The increasing *accessibility* of knowledge resources (indeed, the shift from knowledge *scarcity* to *knowledge abundance*) and the *portability* of knowledge is attributed to the rise of these global and non-state networks in research and innovation (DST, 2005:58). Is it not more a case of information overload than knowledge abundance, because knowledge resides in the tacit memory of an individual?

For this study, the nine drivers of knowledge transfer as identified by Cummings & Teng (2003:54) have been adopted and they include:

1) The perception that knowledge is a valuable resource;

2) The emphasis on getting a return-on-investment in research;

3) The need to close the knowledge gap;

4) The need to extract appropriate knowledge at the right time to make critical decisions;

5) International trade;

6) The need to protect intellectual property such as patents and trademarks;

7) War, terrorism and natural disasters;

8) Geographic proximity between the knowledge source and recipient;

9) The need to protect knowledge for competitive advantage.

The ramifications for each driver of knowledge transfer are discussed in detail as follows.

2.1.1 The perception that knowledge is a valuable resource

Attitude is everything, goes the adage. Perceptions reside partly in attitudes and for this reason, this driver of knowledge transfer is introduced by Williams (1998:209) who provides the following summary of innovative management styles, which is helpful to better understand the attitudes and behaviour of individuals who do, or do not, acknowledge that knowledge is a valuable resource.

Attitudes toward	Expressed values
Risk	Freedom to try new things Acceptance of mistakes Challenge the status quo Positive attitude about change

Change	Ideas are valued Top management support Celebrate accomplishments Respect for new ideas
Openness	Open communication Share information Bright people Gain a customer perspective
Autonomy	Decisions at lower levels Decentralized procedures Expectation of action Quick, flexible decisions

Table 7: Innovative management styles (Williams, 1998:209)

The attitudes and values mentioned above by Williams will strongly influence whether a manager holds the perception that knowledge is a valuable resource and treats it accordingly, or not. The business environment consists of persons who find themselves on various levels from top management down to the employee at the lowest function level. Moorman et al. (1992:318) speak of *dyads* within firms, which are based on their functional area. This functional area determines the type and level of knowledge the individual has to deal with. These authors mention that R&D Managers tend to be more professionally oriented, have longer-term orientation, and have a lower tolerance for ambiguity; while Marketing Mangers are more bureaucratic or organizationally oriented, have a shorter-term orientation, and have a higher tolerance for ambiguity in decision-making. Managers in functional areas perceive transactions differently because of their unique location, training, and expectations. The knowledge useful to these groupings of people will differ dramatically.

Knowledge in firms differs in terms of its value rating. Moorman et al. (1992:317) want to know what knowledge will be constituted to be valuable and usable. Managers may value experience, but

researchers may value only research findings; marketers may value customer information, but non-marketers may value engineering or cost information. This poses certain dilemmas in answering the question of why knowledge would be perceived to be a valuable resource.

The perception that knowledge is a valuable resource invariable focuses on the word valuable and how value can be created. The concept of *shareholder value,* according to Willmott (in Prichard et al., 2000:217) refers to whatever it takes to increase the value of stocks and shares. For management, it means producing and releasing knowledge-cum-information to major players in the financial markets (e.g. fund managers) who make assessments of its credibility and significance for the share price. Who, then, creates shareholder value? Willmott (in Prichard et al., 2000:217) replies that 'everybody who contributes to the process of making assessments about a company's present and projected performance.' So, should a firm, in an attempt to better return-on-investment, decide to transfer technology by spinning-off a company, explains Davenport, Carr & Bibby (2002:243) this decision is usually matched against licensing the technology to an existing company. Thus, the new company option needs to be weighed against the alternative of licensing to an existing company. In addition the relative effect each option will have on successful commercialization, on local economic development, and the envisioned returns (i.e. in terms of research funding, royalties and equity to the parent company) – all these things require careful deliberations.

One way in which firms create shareholder value is to treat knowledge like any other asset on its balance sheet (Davenport et al., 1998:47-8). This indicates the monetary equivalent value of knowledge capital. Thus focussing on how one can increase the stock of knowledge assets over time improves investor perceptions of the organization. Davenport et al. (1998:48-9) reiterate that the following issues surround knowledge assets:

- How to establish the link between knowledge and financial performance;
- The difficulty of quantifying and comparing the economic returns on knowledge assets; and
- Rare evidence of the impact of knowledge assets on organizational performance.

2.1.1.1 Managing knowledge as a critical resource

Leonard-Barton (1988) emphasises the management of knowledge assets as a critical resource. He suggests that firms must concentrate on:

(a) *Knowledge Transferability,* which is the perceived feasibility and how easily it is understood;

(b) *Knowledge Complexity,* or how many sections and members of the organization are involved in the knowledge program; and

(c) *Knowledge Divisibility* refers to the degree in which a knowledge management programme can be segmented so that it may be implemented in stages.

Referring back to literature it is evident that *governance styles* are critical to both universities and their industry partners. What is becoming increasingly obvious, remarks Fleischer (2004:57) is that the managerial focus has increased in terms of 'information and knowledge-based competition as organization's seek to better leverage their value propositions.' The implication is that it is important to invest in knowledge management within the firm so that organizational plus tacit know-how can be incorporated in such a way to enhance university/industry R&D collaborations. But how else can senior management support knowledge management initiatives? Davenport et al. (1998:54) mention three ways, namely that top and middle management must:

- Send messages that knowledge management and organizational learning are critical to the company's success;
- Provide funding and other resources for infrastructure; and
- That management must clarify what *types of knowledge* are most important to the company.

Within knowledge-oriented cultures, such as universities and industry firms, Davenport et al. (1998:55-6) deduce that there is a *life cycle* to building effective knowledge management practices and processes and that because knowledge is closely linked to power in organizations, these knowledge management projects can have significant implications for a firm's power structure. The complexity of human factors to be managed, is often much greater than what is needed for most data or information management projects. The reason being that unlike data, knowledge is created invisibly in the human brain and only the *right organizational climate* can persuade people to create, reveal, share, and use it. Because of the human element in knowledge, a *flexible, evolving structure* is desirable, and motivational factors for creating, sharing, and using knowledge are very important.

This said, it should be realised, however, that effective knowledge management is neither panacea nor bromide: it is one of many components of good management. Sound planning, savvy marketing, high quality products and services, attention to customers, the efficient structuring of work, and the thoughtful management of an organization's resources are not diminished in importance by the acknowledgement that knowledge is critical to success and needs to be managed (Davenport et al., 1998:56). Concluding the finding that knowledge is a valuable resource, Cummings & Teng (2003:42) stress the importance of *commitment* and *knowledge internalization*. Leonard-Barton (1995) supports them by commenting that individuals develop knowledge commitment to the extent that they see the value of the knowledge, and then are able to develop competence in using this knowledge. Commitment and deliberate internalization of

essential knowledge is step one. The second step is maintaining a working relationship or interaction with the knowledge.

Individuals must be willing to put in extra effort to work with the knowledge (Mowday et al., 1979). Cummings & Teng (2003:42) also stress that only when a recipient internalizes knowledge can it be sufficiently understood and adapted by the recipient to allow for its effective re-creation and, ultimately, its use. Then full benefit is derived. These issues impact on shareholder value and resource allocation, but what is more worrying in many firm's across the world is the fact that the mandate to be able to change knowledge destabilizes the ability of today's firm to capitalize on static knowledge. Knowledge is generally vested in workers rather than other physical assets and as such it is very mobile, hence easily available to the competition. Even if retained within the organization, mobilisation of knowledge can be fragile, writes Jacques (in Prichard et al., 2000:203).

2.1.1.2 Knowledge Management Objectives

The objectives of knowledge management projects, according to Davenport et al. (1998:44) are:

(a) To create knowledge repositories;

(b) To improve knowledge access;

(c) To enhance the knowledge environment; and

(d) To manage knowledge as an asset.

One way of doing so, which incorporates the typical goal of knowledge management, is to take documents with knowledge embedded in them – memos, reports, manuals, presentations, articles – and store them in a *repository* where they can be retrieved easily (Davenport et al., 1998:45). In their study Davenport et al. found three basic types of repositories:

- External knowledge (i.e. competitive intelligence where systems will interpret raw information, provide context, filter, and synthesize information from the external environment);
- Structured internal knowledge (i.e. research reports, product-oriented marketing materials, techniques and methods);
- Informal internal knowledge (i.e. discussion databases full of know-how, sometimes referred to as *lessons learned*).

In the business environment today 'misalignment, inadequacies, inefficiencies and constraints of existing systems together with limited time and a lack of the incorporation of knowledge assets in work processes and methods, result in so few benefits being gained' (Tabane, 2005:ii). If organizations do not give systematic attention to the management of knowledge, Fahey & Pruzak (1998:265-6) believe this could inhibit genuine knowledge from being developed and leveraged. Too many firms avoid grappling with a working understanding of knowledge and this leads to a dysfunctional environment for knowledge work. Emphasizing knowledge stock to the detriment of knowledge flow creates difficulties. Knowledge may be viewed as a thing or object that exists on its own, that can be captured, transmitted among individuals, and stored in multiple ways. Knowledge can also be viewed as a 'flow in constant flux and change; largely self-generating such that it connects, binds, and involves individuals,' because knowledge is inseparable from the individuals who develop, transmit and leverage such knowledge (Fahey & Pruzak, 1998:266).

2.1.1.3 Enhancing the knowledge environment

If knowledge is viewed to as a valuable resource, then pro-active steps must be taken to enhance the knowledge environment within firms. One way of doing so mentioned by Davenport et al. (1998:47) is that internal projects should try to build awareness, overcome cultural constraints and build cultural receptivity to knowledge, i.e. to increase awareness of the knowledge embedded in client

relationships and engagements, which, if shared, could enhance organizational performance. Davenport and his colleagues then explain that, at a general level, a process orientation means developing measures of the speed, cost, impact and customer satisfaction of the knowledge management activities, as well as the creation of a decision audit program, which allows one to assess whether and how employees are applying the knowledge to key decisions.

2.1.1.4 The opposite scenario: Knowledge is not treated as a valuable resource

The opposite scenario mentioned by Cloete & Bunting (2000:53) is often characterised by *management paralysis* and in such a firm leadership is ineffectual, decision making is slow and weak, transformation initiatives and processes are narrow and insignificant and within the firm there are institutional struggles and politics; blockages which hinder growth and discourage knowledge creation, sharing and protection.

Williams (1998:174) mentions two costly mistakes that firm managers often make:

(a) The first is an error of *omission*: not understanding the new situation for what it is, thus orienting people in the company to the wrong problem; and

(b) The second is an error of *commission*, which implies that the manager has implemented the new strategy badly, i.e. employees are facing new competitors with new skills and unfamiliar competitive styles.

The goal according to Williams (1998:174-5), is to build into a firm a proactive way of thinking about change, an adaptive capability, where transformation is how the firm creates value is managed effectively on a recurring basis, as the normal way of doing business.

2.1.1.5 South African Perception of Knowledge as a Valuable Resource

In light of the awareness that knowledge is a valuable and tradeable commodity, it is not surprising that higher education institutions in South Africa are displaying an increasing focused move toward *entrepreneurial exploitation* of new market environments. Universities are doing so by accessing a range of resources, extensive industry collaborations (nationally and internationally), and by 'taking advantage of the demand for higher education by non-traditional students through distance education, telematics and flexible learning offerings; in doing so these institutions are perceived to be highly responsive to South Africa's changing socio-economic environment' (Cloete & Bunting, 2000:55). One example is that of the North-West University in South Africa which, in the year 2004 alone, 'earned R870 000 in royalties from six licensing agreements. This university has 76 trademarks, five US patents and 35 patent families. 90% of all research conducted in SA is done at 11 of South Africa's 21 higher education institutions, accounting for 20,5% of South Africa's R&D expenditure[1] – thus academics are turning their research labs into profit-making centres and universities are becoming innovation engines' (Mgibisa, 2006:6, 7).

2.1.1.6 Supporting Policies

Currently the TECHNOLOGY AND HUMAN RESOURCES FOR INDUSTRY PROGRAMME (THRIP) and the INNOVATION FUND (IF) housed in the NATIONAL RESEARCH FOUNDATION (NRF) may be regarded as government policy instruments that indicate that knowledge is a valuable resource in the Republic of South Africa.

In order to bridge the gap between the worlds of education and work, the National Skills Development Strategy and the National Human Resources Development Strategy have been developed and both are articulated in legislation (i.e. The Skills Development Act, Skills Levies

[1] The goal is 1% of GDP expenditure on R&D by the year 2008.

Act, The Employment Equity Act, and the SAQA and FET Acts). Both THRIP and the Innovation Fund clearly articulate this need to bridge the historical divide between the worlds of education and research, and the worlds of work in their mission and strategy (HSRC, 2003:16). In this report the DEPARTMENT OF LABOUR indicates that this bridging was necessary to 'overcome the structural rigidities and inequalities which were inherited from the apartheid era to meet the dual challenges of social development and the requirements to compete in the global economy.'

A brief discussion on THRIP and the Innovation Fund as policy instruments follows.

2.1.1.6.1 THRIP

'The TECHNOLOGY AND HUMAN RESOURCES FOR INDUSTRY PROGRAMME (THRIP) is a programme managed by the NATIONAL RESEARCH FOUNDATION (NRF) for the DEPARTMENT OF TRADE & INDUSTRY (DTI), and it aims to improve the competitiveness of South African industry by supporting scientific research, technology development and technology diffusion activities and enhancing the quality and quantity of appropriately skilled people' (DTI Guide to Research Support: THRIP, 1998).

One primary objective of THRIP is the promotion of increased interaction among researchers and technology managers in industry, higher education and government science, engineering and technology institutions (SETIs), with the aim of developing skills for the commercial exploitation of science and technology; and one of the main criteria to be eligible for consideration is that projects must promote and facilitate scientific research, technology development, and technology diffusion, or any combination of these (HSRC, 2003:18).

In terms of funding, THRIP support is limited to South African Higher Education Institutions and SETIs and the HSRC (2003:20) explain that the four types of funding formulae include:

- R1 for R2: THRIP contributes R1 for every R2 invested by industry in a project;
- R1 for R1: THRIP will fund R1 for every R1 invested by industry under certain conditions;
- SETI-based expertise is contracted into a project with an Higher Education Institution and THRIP contributes a maximum of 30%;
- TIPTOP funding: THRIP contributes 50% (up to a maximum of R100 000 per person on an annual basis) of the cost and the firm will pay the balance.

2.1.1.6.2 The Innovation Fund

The Innovation Fund provides grants to fund end-stage research processes, where research knowledge can be translated into new and improved products, processes or services (HSRC, 2003:21). Two objectives of the Innovation Fund include:

- Encouraging and enabling longer-term, large innovation projects[2] in the higher education sector, government science councils, civil society and the private sector; and
- Promoting increased networking and cross-sectoral collaboration within South Africa's national innovation system.

The Innovation Fund Trust reserves the right to claim ownership of Intellectual Property Rights if, after five years, it is determined that no attempt has been made to exploit the results of the project supported by public funds (HSRC, 2003:23).

The next driver to knowledge transfer, namely the emphasis of getting a return-on-investment, will now be addressed.

[2] The minimum threshold for funding a project is R1 million per year and the maximum threshold is R3 million per year. All parties are required to sign a legally binding Consortium Intellectual Property Agreement (HSRC, 2003:23).

2.1.2 Emphasis on getting a return-on-investment in knowledge assets

Rosenberg (1990:167) pertinently states that research, which is embedded in knowledge assets, is *socially desirable* precisely because these assets often generate such widespread and indiscriminate benefits. A requirement is that market forces allow the firm to capture enough of these benefits to yield a high rate of return on the investment in basic research (which may add to a firm's knowledge assets). After all, if the production of new knowledge generates commercial opportunities to the performer, the relevant calculation involves not the size of the spillovers, but whether the performing firm can capture enough of the benefits generated to yield a high rate of return on its investment. Rosenberg (1990:165) mentions the widely held belief that social returns from basic research are significant and higher than private returns, but he also points out that 'basic research is a long-term investment.' Most firms that have engaged in basic research have had fairly strong and well-entrenched positions of market power, which has enabled them to do so even if the potential pay-off is long-term. It must be remembered that 'not all kinds of knowledge are patentable in such a way as to preclude a competitor from exploiting that knowledge' warns Rosenberg (1990:166-7). This is one reason why firms financing the research have no adequate recourse or mechanism for appropriating the benefits of the research to themselves. This is a distinct drawback from the point of view of industry partners.

With reason Rosenberg (1990:165, 168-9) asks, 'why, then, should private industry be willing to make such expenditures' and the question is a crucial one for the academic-economist as well as for policymakers in both the public and private sectors. Private firms feel no obligation to advance the frontiers of basic science as such. Presumably, they are always asking themselves how they can make the most profitable rate of return on their investment. In biotechnology basic research is a highly speculative game that is being financed by venture capitalists, as well as some large firms and

wealthy individuals, who are lured by the possibility of a very high payoff.

Both university-based research, concerned primarily with the advancement of fundamental knowledge, and industry-based research, concerned primarily with marketable application and animated by the profit motive should serve the general well-being of society albeit in differing ways (Giamatti, 1982:1278, 1279). It is true that the industrial imperative is to garner a profit and this creates the incentive to treat knowledge as private property. When decisions have to be made in firms, busy managers identify the 'most salient information,' according to MacCrimmon & Wehrung (1986:173) and because they have a prominent focus on the expected return-on-investment, even when considerable information is available on variation in returns, chances of gains, and chances of loss, expected return will always receive the most attention. What these researchers' findings indicate is that, in many investment situations the *upside possibilities* can be more important than the *downside risks*. Even when the risks of investment are great, investors should carefully consider the upside potential gain to determine whether the possible gains justify the risks, stress MacCrimmon & Wehrung (1986:173).

Firms strive to protect their proprietary knowledge and to prevent exploitation by commercial competitors. Conceição et al. (2002:26) suggest that firms can compete in two ways:

- One is through the optimization of productive resources in order to gain the market-allowed margins for profit; and
- The second way is to disrupt the market through the introduction of innovations, which give to the innovative firm a temporary absolute advantage over every other firm.

Getting the balance right between profits and protecting intellectual property is always challenging. Bowen (1980:17) explains that an incentive for investment in technology transfer activities is the

attainment of legitimacy through demonstrated alignment with practical societal needs.

At this point the notion of economic time and the effect is has on return-on-investment, deems mention. The concept of *economic time* is described by Williams (1998:ix.x, 5-6, 155 and 157) as follows:

> *'Economic time* is the transforming insight that business time moves at different speeds. The growth engine of every organization has its distinguishing competitive mechanics, and its own dynamic signature that tells how value for it is created, how products age, and how advantage is potentially renewed. Economic time dictates how the organization is set up to respond to market events and economic time determines the pace of research and development.'

'In the multi-speed markets of the new economy, renewal comes about through convergence, alignment, and renewal. Thus, economic time distinguishes companies by their opportunities for growth. It traces the history of the origin of the business. It predicts the means by which advantage evolves through the mechanism of value creation that are distinctive for each company,' expounds Williams (1998:xi). Another way to think about economic time is that it keeps everything from having the same time dependency; it creates priorities. It predicts how your actions are likely to produce moves and countermoves by competitors, where you are strongest in terms of your growth opportunities and where you are most vulnerable. The value of calculating a firm's economic time opens doors to many opportunities for collaborations between universities and their industry partners, for all firms desire their competitive advantage to be like a mighty fortress, stable, long-lived and enduring (Williams, 1998:xi).

One HSRC (2003:66-7) report sums up industry's perceptions of the benefits of the relationship with academia in three quotations:

- 'Competitiveness and technological gain through research and development';
- 'Human Resource development and employment opportunities'; and
- 'Benefits in terms of outputs of relationship.'

Industry often perceives university research as a *hit-and-miss* proposition according to Lopez (1998:226-7), which, if successful, bears fruit, but otherwise is a risky endeavour. Organizing resources and structures to incorporate the participation of industry provides for a greater likelihood for success and a clearer understanding of the goals and objectives of the research endeavours. It is also true that as a firm's technological progress depends upon an increasing number of fields of basic science a firm will increase its basic research, as it mounts efforts in each field (Cohen & Levinthal, 1989a:593-594).

Today capital is increasingly dependent, reports Willmott (in Prichard et al., 2000:218) upon the recurrent generation of knowledge that requires continuous learning and re-skilling. One element mentioned by Kay (in Dozi et al., 1988:284), that may impede efficient linking of external capital (from industry) and internal R&D (from universities) is a possible conflict of interest in information disclosure as far as capital market and product market is concerned, but Mansfield & Kay (in Dozi et al., 1988:284) mention that 'most large firms allocate annual funds to the R&D function on a rule-of-thumb basis such as percentage of sales.'

Lopez (1998:225) rightly comments that university research has a follow-up on consequences that are of industrial relevance and according to him universities in ensuring that research is industrially relevant and gets industrial funding, must address the following issues:

- Identify unique research topics/themes that are of relevance to industry;
- Identifying available physical resources (equipment, space, etc.);
- Identify the organizing structures which will be employed to manage interactions and research results;
- Are standard intellectual property processes and procedures in place and will technology actually be transferred?

If one considers 'the model of the university centre as a *vehicle* for knowledge and technology transfer' Etzkowitz et al. (2000:326) warn that this vehicle is becoming organizationally and institutionally more complex. The reasoning is that universities act as *conduits* through which knowledge exchange and exploitation is made more effective. These issues are relevant because they impact on the drivers of knowledge transfer between universities and their industry partners. The manner in which research is marketed to industry in general, has to provide sufficient indications that a substantial return-on-investment shall be garnered by such R&D collaborations. This brings one to the issue of how science can provide distinct, discernable advantage to industry.

2.1.2.1 The Matthew Effect: Accumulation of advantage

How is advantage (i.e. competitive, brand and market) within firms accumulated by public and private science? In the Gospel of St Matthew it is written that for whosoever has, to him shall be given, and he shall have more abundance. This so-called *Matthew effect* reflects a peculiar type of accumulative advantage in which Owen-Smith (2003:1083,4) has noticed 'the emergence of a hybrid stratification order, where advantage can accumulate within and across academic and commercial outcomes.' Owen-Smith (2003:1086) explains as follows: 'in public science the Matthew effect proceeds through reputation enabled by research capacity. In contrast, accumulative advantage in private science is driven.' Owen-

Smith contends that the accumulative advantage lies in the organizational learning residing in the development of procedures and arrangements for identifying, protecting and managing intellectual property.

2.1.2.2 The role of learning and assimilation

Knowledge management should be regarded as a 'process of reconstruction, rather than a mere act of transmission and reception; for when an opportunity for knowledge transfer manifests, the opportunity to transfer knowledge exists as soon as the seed for that transfer is formed, i.e. as soon as a gap and knowledge to address the gap is found within the organization' (Szulanski, 2000:12-15, 23). It must also be kept in mind that the absorptive capacity of the recipient, i.e. the ability to utilize new knowledge, depends on its existing stock of knowledge and skills, but not only that the more institutionalized pre-existing knowledge is, the higher the effort required to dismantle it. In firms worldwide the result of a lack of knowledge transfer and a lack of learning and assimilation implies a 'lack of motivation which may result in procrastination, passivity, feigned acceptance, sabotage, or outright rejection in the implementation and use of new knowledge' and for this reason (Szulanski, 2000:12, 24) refers to 'an organizational context which facilitates the inception and development of transfers as *fertile* and one that hinders the gestation and evolution of transfers is said to be *barren*.'

Return-on-investment in R&D by firms is strongly influenced by the possibility of acquired learning and the ability of firms to assimilate new knowledge and developments competitively, as was corroborated in Chapter One. Economists conventionally think of R&D as generating one product: new information, but Cohen & Levinthal (1989a:569) suggest that R&D not only generates new information, but also enhances the firm's ability to assimilate and exploit existing information. Thus the *ease* and *character* of learning

within an industry will both affect R&D spending and condition the appropriability regimes and opportunities.

The empirical results of the research of Cohen & Levinthal (1989a:593-4) find that the influence of both appropriability and technological opportunity conditions is affected by determinants of the ease of learning, particularly the targeted quality of knowledge inputs. Some firms invest in basic research even when the preponderance of findings spill out into the public domain. Firms may conduct basic or applied research less for particular results, than to be able to identify and exploit potentially useful scientific and technological knowledge, which is generated by universities or government laboratories. This is done in order to gain a first-mover advantage in exploiting new technologies. Cohen & Levinthal's conjecture is that a product innovation developed on the basis of a well-established underlying knowledge base will diffuse more rapidly among users than one grounded on a more recently developed body of scientific or technological knowledge.

On the other hand Conceição et al. (2002:26) stress that firms through R&D, can institutionalize efforts to search the frontiers of knowledge for inventions or innovations that can translate into new products and processes, so merely responding to market needs may not provide the leading-edge technological superiority needed to introduce really path-breaking innovations. It must be stressed that the innovation process is not linear, nor a direct result of R&D, neither a consequence of predicting market needs with perfect foresight (Conceição et al., 2002:28). Thus the critical point made is that for industry firms the proven quality of the knowledge inputs is extremely significant and will weigh heavily in determining whether or not a return-on-investment will be made. It is evident that participation of industry in the R&D offerings of universities holds distinct long- and short-term benefits for both parties and return-on-investment is one of these benefits.

2.1.3 The need to close the knowledge gap

Irving (1998:1) writes that 'if the world were reduced to a village of 1000 people there would be 584 Asians, 124 Africans; 650 would lack a telephone at home; 500 would never have used a telephone; 335 would be illiterate; 70 would own automobiles; 10 would have a college degree and only one would own a computer. The African continent contains 55 countries and one-eighth of the world's population, but holds only 2% of the world's telephone lines and only one in 5000 people have access to the Internet.' This shocking reality challenges the global village to find ways to close the gap between telecommunications-rich nations and those who lack the means of communicating and transferring information and knowledge.

The situation sketched above ties in with the divide between those who have access to information and the ability to use it, and those who do not; this in turn, ties in with other societal divisions, such as 'the divide between rich and poor, between the educated and the inarticulate, between the majority and minority ethnic, linguistic or religious groups, and between physically and mentally able, and disabled people,' according to Moor (1998:281). Some may disagree, but McKinley (in Prichard et al., 2000:107) is of the opinion that 'knowledge always empowers the already powerful, mostly because there is an acceptance of the gap between power and knowledge – a gap occupied by tacit knowledge and unregulated social processes.'

In mentioning the issue of power in firms which resides in knowledge assets, Offsey (1997:114) provides an interesting classification of corporate knowledge assets. He groups these knowledge assets as follows:

- Process orientated;
- Function assets; and
- Conceptual assets.

This seems a rational assumption with sound boundaries for each. Bridging the knowledge gap in each of these asset groupings could, however, be quite challenging.

2.1.3.1 "Information famine" or "information glut"?

Corporate knowledge silos and the barriers they erect contribute to a perceived lack of information and this condition results in *info famine*. Offsey (1997:114) also indicates that most knowledge workers have access to too much information, which is on the opposite side of the continuum and referred to as *info glut*.

There are two dangers involved with knowledge transfer between universities and their industry partners and the first danger is an over-preoccupation with information and knowledge. The second danger is knowledge intensity. In firms that have an over-preoccupation with information, Alvesson (1999:1010) writes that people are often 'over-concerned with information' and this strong emphasis on information is grounded in the fact that most individuals, and many industry firms wish to appear very careful, rational, reliable, advanced, progressive, responsive, and intelligent. Upholding this image and reputation is important and one way of doing so is for individuals and firms 'to remain plugged in to the scientific network as a participant in the research process,' because this signals your capabilities as you perform relevant R&D (Rosenberg, 1990:171 and 172).

In terms of knowledge intensity, many authors acknowledge that knowledge is very difficult to define, but nevertheless they treat knowledge as a 'robust and substantial capacity, which has the ability to produce good results.' Based on this statement Alvesson (1993:1001) claims that a knowledge intensive organization is thus a firm that can produce exceptionally good results through the help of outstanding expertise. A key characteristic of knowledge-intensive organizations is said to be the capacity to solve complex problems through creative and innovative solutions (Hedberg, 1990; Sveiby & Risling, 1986). Alvesson (1993:1000-1) writes, however, that creativity is especially needed when knowledge is insufficient and

often, when we have enough knowledge we do not have to be creative. Therefore, a knowledge intensive organization is a firm that can produce exceptionally good results through the help of outstanding expertise. By implication industry firms are encouraged to make use of the available expertise located in universities. The challenges lie mostly in being proactive about retaining and expanding both the opportunities and capacity for explicit and tacit knowledge transfer within firms and between universities and industry partners. Keeping communication channels open remains paramount. Challenges also lie in addressing *complexity* and *scalability* issues; in finding ways of overcoming internal organizational rigidities; in full utilization of media and other methods of communication and last, but not least, in ensuring that the likelihood of industry partners benefiting from R&D done by universities is boosted.

2.1.3.2 Knowledge Gaps and Technology Chasms

The knowledge gap includes the innovation chasm. Komives & Petersen (1997:83) explain that 'the innovation chasm is the innovation gap that exists between knowledge generators and the market, and includes tactical attempts to close the innovation chasm by connecting the human capital function (provided by universities) more and more closely with the market.' This comment is in line with the focus of this research project on the drivers of knowledge transfer. These drivers bring industry partners in the market closer to universities, which provide not only R&D, but also human capital.

A DST (2002:35) report confirms the above statement as a reality in South Africa by stating that 'well-financed research at universities and research organizations can and should develop and retain an excellent talent pool.' Vest (in Clark, 1998:146) sympathizes with the fact that the modern research university has become 'over-extended, under focused, overstressed and under-funded' making it very difficult to deliver outstanding research outputs.

2.1.3.3 Information Communication Technologies (ICT) in the knowledge gap and digital divide

The drivers of knowledge transfer between universities and industry firms are impacted by various factors. Africa is notorious for its low levels of development and the continent is constantly in the news because of reportage on natural disasters, conflicts, state wars and military intervention. Botswana, Mauritius and South Africa are of the few countries deemed to be potentially viable in development terms, so 'structurally weak African countries face the unending threats of marginalization and total exclusion in the global economy' (Boafo-Arthur, 2003:27). South Africa is challenged to become more economically viable and to ensure sustainability of R&D and knowledge transfer in general.

Furthering the argument about the knowledge gap, what is evident is that the digital divide can come across as marginalising and patronising, no matter how well intentioned the action is to bridge it. Technology alone cannot bridge the digital divide, though Information and Communication Technology (ICT) as an important enabler is woven into social systems and processes, it still needs to be complemented by other resources and social interventions to create inclusion and transformation of societies. ICT has a powerful reach, but alone it does not and cannot provide a solution to the problems caused by globalisation. What South Africa needs is applicable technology, plus information rich content, plus the resources and infrastructure, to provide a solution, i.e. to allow rich and poor individuals, firms and communities can 'participate in societal offerings, information and benefits, and so gain control over their own destinies and share in collective resources' (Warshauer, 2002:6-7).

Levitt (in Mitchell, 2003:26-27) reminds us that it is a mistake to believe that as new media and technology shrink the world, people's tastes converge creating a single global market that is dominated by the world's most popular brands. What is true is that 'the overwhelming desire for dependable, world-standard modernity (i.e. life-alleviating technologies at lower cost) in all things, and at

aggressively low prices' is what the global market wants. South Africa with its technology-follower status has a long way to go in terms of invention and innovation and its racial, language, literacy, educational and social divisions challenge the country.

Pires-O'Brien (2000:265) indicates that South Africa is challenged together with the rest of Africa to seek sustainable solutions, which will enable it to leapfrog into the technological future and allow the continent to participate fully in its offerings. This can be done if universities and collaborating industry firms create viable and sustainable platforms in communities that will give them access to relevant economic, medical, financial, agricultural and other information and thereby enable them to withstand and reduce or alleviate poverty. Information needs to be contextualised for Africa. This will make the information provided applicable, more accessible and understandable for the African context.

2.1.3.4 Information Poverty in the Knowledge Gap

Information poverty is a complex social and cultural phenomenon, because different people inhabiting the same physical environment, might, because of their backgrounds, experiences and knowledge, interpret the same information in different ways (Chatman, 1996:192). Britz & Blignaut (2001:66, 69) concur by pointing out that 'information poverty is a multi-faceted developmental problem that needs a multi-faceted solution, because information poverty relates to the availability and accessibility of essential information that people need for development and that it is closely linked to a person's ability or inability to understand and interpret information.' Therefore Britz & Blignaut are of the opinion that information poverty can be seen as an 'instrumental form of poverty' affecting all other spheres of life. How can it be addressed? These authors recommend *economic liberalisation,* which in a country like South Africa must manifest in sound policies and a working social and educational system as well as an investment in technology, and the sustained use of the

environment. Our technology colony status indicates that we have sustainable resources, which must be deployed.

The above should occur within an appropriate moral and ethical framework that addresses inequalities, where the role of government is to create equal opportunities – not to secure equal material positions for everyone (Britz & Blignaut, 2001:70). What potential solutions exist that can address these knowledge gaps? Moor (1998:289) suggests the following sensible principles to ensure *universal access* at reasonable cost:

- An interconnected and interoperable network of networks;
- Collaborative public and private-sector development;
- Competition in facilities, products and services; and
- Lifelong learning as a key design element of the information highway.

One possible way of bridging the knowledge gap between universities and industry firms in general, may include the creation of new organizational knowledge, which provides the basis for organizational renewal and sustainable competitive advantage (Inkpen, 1996:123-4). It is a learning imperative. Knowledge creation is a dynamic, continuous process, which involves interactions at various organizational levels and sometimes the process is haphazard and idiosyncratic. How is knowledge created? Inkpen (1996:137, 139) writes that knowledge is created:

- Through organizational *processes;*
- Through the organizational climate, which facilitates the effective implementation and utilization of the knowledge management processes;

- Such knowledge creation efforts must be balanced by the *cost* of doing so, because knowledge creation is more *incremental* in nature than a *home run* type of learning.

The reason why alliances provide firms with a unique opportunity to leverage their strengths with the help of partners is because alliances provide firms with a window on their partner's broad capabilities. This knowledge can then be incorporated into the firm's wider organizational knowledge base, system and structure, through a process of *grafting*, allowing the firm to internalize a wealth of new knowledge, not previously available within the organization. Alliances (with universities for example), allow a firm to incorporate disparate pieces of individual knowledge into a wider organizational knowledge base (Inkpen, 1996:124).

Some general knowledge access mechanisms mentioned by Almeida et al. (2003:301) include, 'the hiring of scientists and engineers, the forming of strategic alliances and the appropriation of informal networks.' These aspects carry the potential of bettering knowledge transfer between universities and their collaborators in industry. Acquiring external knowledge is an incentive to firms as was seen in Chapter One and such external knowledge, according to Almeida, Dokko & Rosenkopf (2003:302) can be acquired through:

(a) Expert mobility;

(b) Alliances; and

(c) Informal geographically mediated networks.

These authors reason that with increased size, start-ups may be able to source and use more knowledge from external sources because of the greater opportunity of doing so and also because of the greater available scale and scope, which provides them more linkages to the outside world together with a greater potential to exploit knowledge internally.

Knowledge gaps exist between people on all levels and in all areas of functionality. An interesting finding of Almeida et al. (2003:311) is that 'while mobility and geographic similarity increase inter-firm knowledge flows, these effects decrease with firm size.' Also the usefulness of alliance formation does not change with firm size. It appears that the negative effects of size, such as myopia and rigidity, manifest via more informal mechanisms.

Concluding the argumentation on the necessity of closing the knowledge gap one has to reiterate that the divides in South Africa between the educated and inarticulate, the role played by *info famine* and *info glut*, the power plays evident in decision-making circles and how ICT either betters or worsens the situation in South Africa, all impact to a greater or lesser extent on determining whether this chasm can, and ever will, be bridged.

2.1.4 The need to extract appropriate knowledge at the right time to make critical decisions

Getting the right information to middle and top management at the right time and in the right format, sounds good in theory, but this remains one of the most serious complaints, and areas of stress and uncertainty, of decision-makers at all levels within firms. There are astounding amounts of information available, but too often decision-makers have no time to sift through the deluge to extract the nuggets of information, which will enable them to make sound decisions. Decision-makers often lack the skill of identifying the information, which has the capacity of impacting severely on business decisions. It is only with hindsight that one may realize that the information you possessed at a given point, upon which a decision was based, was lacking, dated, erroneous or even falsified.

Some questions asked by Fahey & Pruzak (1998:275) remain valid in firms today, for example:

(a) What errors may reside in what we think we know?

(b) What might be the consequences of these errors?

(c) How might we rectify these errors?

The answers to these questions may differ from firm to firm and from industry sector to industry sector, but knowing the answers implies that appropriate information must be made available upon which sound decisions can be based. Furthermore managers must be vigilant about detecting and correcting errors in their processes of knowing – the generating, moving, and leveraging of knowledge throughout the firm (Fahey & Pruzak, 1998:275).

2.1.4.1 Knowledge Silo's

Offsey (1997:114) mentions that organizations create and maintain knowledge in isolated systems (or knowledge silo's), which provide adequate functionality for specific workgroups or business processes, but these systems are unreachable by others in the organization, because in many instances the information is invisible or inaccessible to others who need it. For various reasons this is a persistently problematic situation within firms, which impacts negatively on decision-making, productivity, trust relationships and individual motivation and performance.

2.1.4.2 The Role of Learning

Instinctively most people, who find themselves in the economically active portion of society, are keen to learn in order to be empowered to complete tasks, among other reasons. If learning, for our purposes, can be seen as a process of remembering, one must keep in mind that individuals are inclined to only remember that which they are interested in, firstly, and secondly, information which allows them to participate sensibly in their work and social environment.

This implies that people will instinctively focus on knowledge they need to make critical decisions on a continual basis, be it financial, marketing, sales or competitive knowledge. They will also be keen to have someone transfer this knowledge to them. The ideal is that the acquired knowledge should communicate information, which is instructive, descriptive and easily understood. Children are often

admonished by parents who say it is better to keep your mouth shut and appear stupid, than to open it and to remove all doubt. In the working environment this behavior is evident too, but very dangerous and a wasted learning opportunity. The ideal is that individuals and firms should bridge ignorance by learning. Learning also removes information anxiety and aids in transfer of knowledge – both tacit and explicit.

Conceição et al. (2002:29) are of the opinion that 'organizational learning is equated with a firm's ability to accommodate changes (e.g. of products, technologies and markets) and in this milieu learning occurs both at *people level* and at *unit level*.' These authors explain:

> 'People learn by increasing their human capital (through education, training, experience, expanding their networks of personal contacts). Learning at the unit level is reflected in increased productivity, resulting from scale-effects, better communication, and establishment of routines, among other possibilities. Encompassing the way people and units learn is the system of incentives, rules of conduct, guidelines and informal norms of behaviour that surround the firm's activity' (Conceição et al., 2002:29).

On the topic of extracting appropriate knowledge in time to make sound decisions, it is worth mentioning that if knowledge is perceived to be accumulated or processed information then Cohendet et al. (1999:228) write that this implies certain levels of learning. Andreu & Ciborra (in Cohendet et al., 1999:228) suggest that there are three loops or levels in learning processes in firms that allow new competences to emerge. These levels are:

- The routinazation learning loop where standard resources are used to increase efficiency.
- The internalization of a new work practice or organizational routine using a tacit routine on a systemic level.

- The third strategic loop is where new core competences emerge.

Universities can assist firms in bettering all three these loops, for example by innovative resource utilization and tacit knowledge capturing techniques and this in turn can positively impact not only on productivity, but also on their return-on-investment in R&D.

2.1.4.3 Sense-making in Organizations

Within firms it is important to focus on how people extract meaning from organizational information. Sense-making mechanisms are used by organizational members to attribute meaning to events according to Sackman (in Fleck, 1997:389) and she explains that these mechanisms include the standards and rules for perceiving, interpreting, believing, and acting that are typically used in a given cultural setting. Based on the underlying commonalities of these sense-making mechanisms, the essence of culture can be conceptualized at the collective construction of social reality. Thus, in order to extract appropriate knowledge, sense making as a complicated, holistic process will incorporate the cultural and social reality, existing knowledge, own perceptions and instinctive judgements. In this respect Snowden's (2005:3) Cynefin model of sense making in complex environments refers. Snowden explains that the name Cynefin refers to 'the place of our multiple belongings; the sense that we all, individually and collectively, have many roots: cultural, religious, geographic, tribal, etc., which profoundly influence what we are.'

'Sense making is the way that humans choose between multiple possible explanations of sensory and other input in order to act in such a way as to respond to the world around them' (The Cynefin Centre, 2006:1 and Neves, 2003:1).

2.1.4.4 Teamwork in Organizations

In the working environment of organizations the process of extracting appropriate knowledge in order to make sound decisions can be

bettered when specialized knowledge workers come together in teams, which are often referred to as *Communities of Practice*.

It is evident from literature that the size and mobility of the science and engineering labour pool in a region increases localized spillovers (Almeida & Kogut, 1999) and strategic alliances among firms increase the likelihood of such spillovers, according to Almeida et al. (2003). Interestingly enough the research done by Brown & Duguid (1991) found that *industry secrets* are often situated in informal communities of practice. People talk. At conferences, workshops, informally, in the workplace, at meetings and more than just the reason for being at the event, is discussed. Communities of practice contain a wealth of tacit knowledge, which is shared between sources and other recipients of knowledge.

Breen (2006:2) quotes Senge, who co-authored the book, PRESENCE: HUMAN PURPOSE AND THE FIELD OF THE FUTURE, in which he identifies '*presence,* as not just being fully conscious and aware in the present moment, but also as *deep listening*; of being open beyond one's preconceptions and historical ways of making sense, as well as the importance of letting go of old identities and the need to control.' Geographic proximity between the stakeholders within these communities of practice is of no consequence, because contact between them can occur more or less instantaneously, irrespective of time or place.

Communities of practice, in the opinion of Kazanjian et al. (2000:289), create an environment where individuals feel comfortable and motivated to engage in the creative process, and where they have access to the skills and resources to pursue creative approaches and designs. This is of particular importance when extracting information in order to make quality decisions. A crisis occurs when the structure of a social system allows for fewer possibilities for problem solving than are necessary for the continued existence of the system firstly, and secondly a crisis can result from exogenous environment changes, such as a new feature on a competitors product, the loss of

a critical supplier, or a shift in demand writes Kazanjian (2000:289). Thus there are pro's and con's to using teams to extract appropriate knowledge.

Within the university milieu relevant knowledge structures which arise can be seen as a synthesis of patterns of experience in the physical world (Inzák, 2000:70, 71) and one's understanding of the physical world (i.e. in this case the represented reality of industry partners) and these understandings can both support and constrain development. Thus university researchers must be intimate with the world in which their industry partner functions and their R&D collaborations should be inventive in finding sensible ways to foster and expand knowledge.

2.1.4.5 Challenges in Knowledge Extraction

Extracting appropriate knowledge is not without its challenges. Cohendet et al. (1999:227-8) are of the opinion that 'evolution [which is built upon the principles of heredity, mutation and selection], is driven by the generation of diversity, shaped in turn by mechanisms of selection and the firm is viewed as a locus where competences are continuously built, managed, combined, transformed, tested and selected.' The South African reality with huge language and cultural divisions that manifest in the workplace, necessitate a continuous process of knowledge creation and shaping which, more often than not, is driven by problem-solving activities.

In a system where knowledge is managed, it must also be kept in mind that one must integrate both the tangible and structural aspect (i.e. the codified part of knowledge), together with the intangible social aspect of knowledge, which includes tacitness, spontaneity, intuition, values and beliefs. This is particularly hard to do, but if firms simultaneously employ 'a social approach to capture the tacit component (by way of joint understandings and collective language development) and the structural approach to capture the codified component, these dimensions will serve as a continuum of exchange' (Revilla et al., 2005:1311).

2.1.4.6 Competences

One cannot talk about extracting appropriate knowledge without mentioning the competence within firms to exploit the information gathered, which either results in the firm having/gaining a competitive advantage, or it results in them losing that advantage. What exactly is meant by competences and what makes a firm and a decision-maker competent to make decisions? Based on Guilhon's definition of competences as 'sets of routines, of differentiated skills, of knowledge (and the ability to combine these sets of knowledge) and secondary assets that express the efficiency of problem-solving procedures,' Cohendet et al. (1999:229) stress that competence expresses *what a firm can do*. Teece (in Carlsson & Eliasson, 1994:693) provides a broader definition of competences when he writes: 'Core competence is a set of differentiated skills, complementary assets and routines that provide the base for a firm's competitive capacities and sustainable advantage in a particular business.' The challenge is to retain and transfer component knowledge (Teece, 1998:56; Hamel et al., 1989 and Hamel & Prahalad, 1989).

In summary of this driver of knowledge transfer it can be said that the ability of firms to make sound decisions depends on their internal competences of extracting appropriate and relevant knowledge in the course of their interactions and collaborations with universities, clients and suppliers, and through their internal learning and internalisation activities as well as their problem-solving procedures.

2.1.5 International trade

The next driver of knowledge transfer, which needs to be addressed in this dissertation, is that of international trade. International trade, however, is an extremely broad topic, so for the purposes of this research project only the following issues will be addressed:

- Diversity, connectedness and ethnicity versus the global "us";

- GATT: Its rules, TRIMs, special and differential treatment and multi-lateral trade negotiations;
- Motivations for foreign direct investment; and
- The potentiality for productive knowledge transfer in South Africa.

By way of introduction it makes sense to look at the broader picture first and to then focus on how international trends impact on South Africa. 'The acceleration of trans-border trade and information technology has diluted the state's influence as a platform provider' (Long, 2002:325). Shuja (2001:257) commenting on the issue writes that 'a heated pursuit is evident towards economic advancement and competition for resources and technology.'

2.1.5.1 Diversity, connectedness and ethnicity versus the global "us"

Breen (2006:2) in discussing his perspective of the business landscape in South Africa comments that:

> 'South Africa's business landscape is dominated by a drive to enhance the workforce diversity in our companies. *Diversity* is becoming a key factor for competiveness globally, with organizations operating in intensely competitive and complex conditions needing rich information processing. A diverse community is a resilient community. Diversity in South Africa remains defined largely in terms of race and gender – necessarily due to the nations past – but firms should also be aware that diversity includes other differences, such as in national origin, ethnicity, ability and even geographic origin.'

Friedman (1999:376, 377) would prefer it if 'communication could reflect individuality, and one's particular links to a place, a community, a culture, a tribe and a family.' The diverseness of cultures and languages in South Africa poses huge challenges in terms of

knowledge transfer, but correctly utilized can probably be one of our greatest strengths. This is by no means unique to South Africa, however. An international trend noticed by Scholte (2000:165) is that nation states choose to bear the economic costs of defying globalizing pressures to reaffirm their *cultural distinctiveness*, so it is understandable that there is resistance to policy convergence, especially in view of the fact that 'the form, legitimacy, sovereignty and power of the state is increasingly threatened' (Bornman & Schoonraad, 2001:104). This is the case because of changes in the complex international links that ignore social and political borders; the impossibility of controlling or limiting the free flow of information; the trans-national mobility of corporations, capital, technology, which enables the private sector to ignore and evade national legislation and regulations, and as such globalisation thus undermines the emotive and normative values of connectedness to a particular nation state. Capra, in his book, THE WEB OF LIFE (1996) writes about diversity and the effect of globalization and Breen (2006:2) commenting on the book suggests that there are four areas in which organizations can emulate ecosystems in order to maximize diversity and connectedness. These areas are:

(a) Interdependence;

(b) The cyclical flow of resources;

(c) Co-operation; and

(d) Partnership.

2.1.5.2 The General Agreement of Tariffs and Trade (GATT)

The *General Agreement of Tariffs and Trade* was established in 1947 to reconstruct a multi-lateral system of world trade and its norms and rules were geared toward ensuring the maintenance of an open, non-discriminatory market in which government intervention is minimized and tariffs and prices guide the decisions of private firms (Haus, 1991:163). Tariffs and prices, however, have little or no influence

over decision-making in planning economic systems in which decisions about resource allocation, imports and exports are administratively determined by government. *Trade related investment measures* (TRIMs) have the potential to alter the nature of foreign direct investment, which is an important source of capital inflows to developing countries (Morrissey & Rai, 1995:702-3).

2.1.5.3 Motivations to engage in Foreign Direct Investment

There is a focus on university/multinational firm interaction in terms of potential knowledge transfer and both universities and firms in South Africa would have a vested interest in collaborating with SME's, local corporates as well as multi-national firms. What are the reasons why trans-national corporations wish to engage in foreign direct investment in developing countries such as South Africa? Some possible reasons mentioned by Morrissey & Rai (1995:705) might be:

- The developing country may offer commercially profitably investment opportunities;
- Developing countries are often rich in certain resources;
- Many developing countries have sufficient and relatively cheap labour and this is particularly attractive for manufacturing trans-national corporations;
- Locality can be another draw card, especially in terms of manufacturing production facilities and access to infrastructure. This is then a location-specific benefit;
- Another reason may be the access that developing countries can provide to large host markets;
- Firm-specific benefits may accrue for the trans-national corporation, for example in terms of a patent or a particular technology;

- Another issue, which is easily overlooked, is that of the 'gains to be made from internalization' (Dunning, 1981). In effect what this means is that a trans-national corporation must make a decision on whether they will produce a product themselves or whether they will employ a local firm to do so and then handle the transaction by way of a licensing agreement or by way of a joint venture contract. This first option goes the route of foreign direct investment and obviously a firm will only go this route if the benefits in keeping production in the firm far exceed the benefits of using an external production facility – this is the opinion of Morrissey & Rai (1995:705).

2.1.5.4 The potentiality for productively transferring knowledge in South Africa

Abramovitz (1986:385-6) notes that there is a 'backlog of unexploited technology in the West', which by way of catch-up, carries the potential for rapid advance via knowledge transfer, because it has to do with the level of technology embodied in a country's capital stock. South Africa with its technology colony status, good resources and infra-structure, thus has the opportunity to leapfrog its economy by latching on and catching up to the first world. On the other hand the process may not be plain sailing, because of *potentiality*. The process of potentiality, according to Abramovitz (1986:390) depends on the following critical issues:

- 'The facilities for the diffusion of knowledge – for example, channels of international technical communication;
- Conditions facilitating or hindering structural change in the composition of output, in the occupational and industrial distribution of the workforce, and in the geographical location of industry and population; and
- Macro-economic and monetary conditions encouraging and sustaining capital investment and the level and growth of effective demand.'

Thus, Abramovitz' research shows that differences among countries in productivity levels create a strong potentiality for subsequent convergence of levels, provided that countries have a *social capability* adequate to absorb more advanced technologies. 'The state of a country's capability to exploit emerging technological opportunity depends on a social history that is particular to itself and that may not be closely bound to its existing level of productivity' (Abramovitz, 1986:405).

The relationships between universities and their industry partners are impacted upon by the possibilities for trade. Smith (in Dozi et al., 1988:413) argues that trade has a beneficial effect upon the rates of macro-economic activities and employment because the enlargement of the market due to international trade feeds back upon the domestic division of labour and thus on the trends in productive efficiency. Latching onto the discussion Ricardo (in Dozi et al., 1988:421) proposes that 'no extensions of foreign trade will immediately increase the amount of value in a country, although it will very powerfully contribute to increase the mass of commodities, and therefore the sum of enjoyments. As the value of all foreign goods is measured by the quantity of the produce of our land and labour, which is given in exchange for them, we should have no greater value if, by the discovery of new markets, we obtained double the quantity of foreign goods in exchange of a given quantity of ours.'

In consequence it bears underlining once again the general *objective* of the international trading community, which, according to Baldwin & Thompson (1984a:275) is to 'establish a self-enforcing behaviour framework in which responses by individual members discourage any single member from pursuing actions that distort the allocation of world resources.' Krugman (1983) agrees with Baldwin & Thompson (1984b:275) when he points out that there is a case for providing government support for R&D-intensive, technologically progressive industries, because 'investment in knowledge in these sectors produces knowledge benefits in other firms and sectors.'

2.1.6 The need to protect Intellectual Property

Moving to the next driver of knowledge transfer, namely how Intellectual Property can be protected by universities and industry firms, it can be said that endeavours to protect intellectual property through patents and trademarks have been an area of contention between universities and industry for years. Edvinsson & Malone (1997:22) stress that 'intellectual capital is our future.' Yakhlef & Salzer-Mörling (in Prichard et al., 2000:23-4) agree and add that 'intellectual capital is the fount from which financial results are generated, but their concern is with prevailing valuation techniques, which they say are problematizing and marginalising.' Furthermore one of the organising principles underlying the discourse on intellectual capital is that of division and separation, as it yields two classes: human capital and structural capital.

Edvinsson & Malone (1997) define *human capital* (shared and individual) as 'the value of everything that 'leaves the company at five p.m. because it can walk through the door and never come back; whereas *structural capital* is everything that remains within the company after five p.m. and this includes customer capital as well as organizational capital, which is both innovation and process capital.'

2.1.6.1 Managing Intellectual Capital

Using Edvinsson & Malone's (1997:44) definition of *intellectual capital* as 'the possession of the knowledge, applied experience, organizational technology, customer relationships and professional skills that provide companies with a competitive edge in the market,' it can be said that knowledge management is a sophisticated way for an organization to share intellectual assets (McInerney & LeFevre in Prichard et al., 2000:16).

So then 'what is knowledge? Where does it reside? How does a firm secure it, spread it, develop it, manage it, measure it?' These are some of the pressing questions posed by Yahlef & Salzer-Mörling (in Prichard et al., 2000:21). The ultimate aim in the opinion of these

authors is to 'displace knowledge from the body it inhabits to the balance sheet,' where it is meant to feature as a new type of capital, commonly referred to as *intellectual capital*, which rivals and eclipses the traditional concept of financial capital. This statement neatly sums up why knowledge has to be protected and what needs to be done to secure it for competitive advantage. After all, the aim of most firms today is to turn knowledge into *a calculable asset* (Yakhlef & Salzer-Mörling in Prichard et al., 2000:20), because reducing knowledge into numbers explains Miller & Rose (in Prichard et al., 2000:22) 'has governing potential' as it calls for calculations and knowledge therefore affects productivity and shareholder value.

At this juncture this driver of knowledge transfer will be looked at from both perspectives (i.e. industry's perspective as well as that of Higher Education Institutions), but first some general comments on patenting as an important sub-section of intellectual property protection as a driver of knowledge transfer. 'The patent system is an exemplar of organizing knowledge as a public and private good, at one and the same time' (Etzkowitz et al., 2000:327), because concepts and technologies are made accessible to others. The difficulty lays in the social norms of science, including the emphasis on priority, which McMillan et al. (2000:4) points out, may actually provide more protection to innovations than legal methods, such as patenting and trade secrets.

The demand for measures of inventive outputs has increased dramatically over the past two decades, confirms Sampat & Ziedonis (2004) and Moed et al. (2004:277), but the difficulty lies in 'knowledge spillovers which are not directly observable and thus difficult to quantify.' Trajtenberg (1990:189) proposes that a patent that has been revealed to be profitable will induce other firms to undertake research in technologically close, but non-infringing areas, while Sampat & Ziedonis (in Moed et al., 2004:280, 281) hypothesize that citations represent the portion of social return appropriated by the patent holder and secondly that 'citations reflect entry into profitable areas of research.'

The suggestion made by Almeida et al. (2003:312) is that while patents may themselves represent codified knowledge, patent citations allows us to observe the end points of the knowledge building process, regardless of whether the knowledge building involved the application of tacit or codifiable knowledge. Citation accounts appear to reflect the asset value of patents, or the price at which surveyed patent owners reported they would be willing to sell the rights to particular patents (Sampat & Ziedonis in Moed et al., 2004:282, 295). Thus citations do reflect market interest in areas in technological proximity to particular patents; however as innovations and commercialization are uncertain activities, the level of revenues ultimately earned by particular technologies may be influenced by factors other than market interest, including competition by competing technologies, licencees' commercialization activities, and R&D and marketing competencies.

2.1.6.2 Industry's perspective on patenting

One measure of firm output is the level of patenting activity in firms (Löfsten & Lindelöf, 2005:1033). Decisions made in this regard determine what a firm's overall strategy will be. The explicit strategy of some firms is to limit patenting, because they 'lack the financial clout to police their patents effectively' (Boisot, 1995:489). This decision is to be respected if their focus lies elsewhere and resources pose a problem. Firms want to get a return-on-investment in R&D and their need to appropriate benefits foregrounds the issue of *ownership*. The critical question asked by firms is: To whom are intellectual property rights assigned in terms of patents and licenses?

Arrow (1962:175-179) notes that 'pre-invention monopoly profits, weaken the incentive to invent' and the only way to strengthen those incentives is by offering the firm that conducts the research a proprietary control (e.g. patent rights).' Arrows' argument is based on the surmise that 'once knowledge has been produced, it is costlessly available for other firms to utilize as well.' This is not entirely true

because much information within firms is proprietary and protected, but in essence certain information should be freely available.

The protection of property rights and lags required for competitive response are critical elements in deciding whether or not to adopt an offensive strategy, points out Kay (in Dozi et al., 1988:288) and in this respect he clarifies that a 'defensive strategy is still likely to involve a high level of R&D, but the firm is prepared to react and follow offensive innovators, possibly with some degree of differentiation.' Another author, Freeman (in Dozi et al., 1988:178), contributes to this discussion by pointing out that a science-based firm's R&D strategy may contain mixtures of *offensive* and *defensive* strategies. In the case of industry, patent ownership becomes valuable only after a resulting product has demonstrated sufficient value to be sold in large quantities (Blumenthal, 1986:3346). After all, short- and long-term profitability affects the bottom line and sustainability of staying in business, so this is a valid point.

2.1.6.3 University's perspective on patenting

In the first instance it is important that patents held by academics should be regarded as evidence of *quality research*, stresses Etzkowitz et al. (2000:320,325), but these authors have another concern, namely 'whether academics are willing, or able, to protect and commercialize their discoveries.' This brings us back to the traditional view that universities should be focussed on quality education and research and should leave business to industry.

McMillan et al. (2000:2-3) mention that they perceive that technology production is localized by nature and that geographic proximity is important, but that the unending quest for priority may cause inefficiencies in the allocation of basic versus applied resources. Part of this inefficiency emanates from the constant friction between academic institutions who desire publication and the establishment of priority, and corporate research sponsors who wish to defer disclosure until appropriate mechanisms (i.e. patents, etc.) can be employed to protect the future economic returns of an innovation.

In so many instances 'organizational learning stratifies patenting success,' and patenting also increases the reputation and visibility of the university's published research, but moreover Owen-Smith (2003:1085, 1093) points out 'academic reputations are parlayed into patenting success without damage.' Indeed, the relative stability of this group's reputations across time periods suggest that far from being contradictory, public and private science outcomes became complementary over time. The reputations of universities such as Cambridge Massachusetts Institute of Technology (2006), which has a strong patenting base and respected business acumen, are at stake. 'One advantage of using university data for studying the relationship between patent citations and economic value is that, unlike the private sector, the university lacks the requisite complementary assets and the motive to engage in product development and marketing activities to capture economic value, therefore, universities typically apply for patent protection solely for the purposes of licensing inventions generated by research, for licensing is the primary means through which universities can appropriate social returns' (Sampat & Ziedonis in Moed et al., 2004:282-3, 295). The primary finding in the research of these authors is that whilst patent citations are good predictors of whether a university patent is licensed, they are not good predictors of the license revenues earned by technologies conditional upon its licensing.

What Owen-Smith (2003:1096) suggests is the integration of public and private science reward systems as research capacity returns to patenting accrue only through the indirect mechanism of academic reputation. Extensive patenting enables universities to leverage higher public science status from private science accomplishments; and in turn this increased prestige pays dividends in research capacity. Once again the status and reputation of the institution are mentioned. Sine et al. (2001) coined the term - the *halo effect* in university patent licensing. Owen-Smith (2003:1096), who cites Sine et al., explains that this halo effect implies that 'institutional prestige

leads to increased licensing revenues, which in turn, lead to greater patenting productivity.'

Several South African universities are becoming incentivized to pursue patents. In some instances writes Feller (1990:338) 'a university's aggressive technology development strategy involves encouraging (and assisting) faculty to seek patents for their research more assertively, and to undertake (relatively) more patentable research; to more actively seek to license patents assigned to the institution; and to enter into more equity arrangements with firms wishing to commercialize faculty research.'

Feller (1990:338-9) then goes on to describe three distinct, albeit related items that go hand in hand with patenting of academic research, which is both effective and lucrative:

(a) The number, rate of increase, and distribution of university-generated patents among fields of knowledge;

(b) The income stream generated for universities through the licensing of patents and/or participation in firms that seek to commercialize those patents; and

(c) The impacts that both (a) and (b) have on the characteristics of academic research, the rate of diffusion of academic research into commercial uses, and the processes by which this transfer occurs.

2.1.6.4 Knowledge Spillovers

'There is a widespread belief that knowledge spillovers are an almost costless and frictionless process' (Howells, 2002:875). Where knowledge has been considered in this tradition, it has been treated as a public good that is easily transferred between people and organizations. Thus, 'knowledge was seen as a public good because it was seen as being impossible for its creator to prevent it being used by economic agents who do not pay anything in exchange for it' (Saviotti, 1998). On the other hand, Feldman (1994) concludes that

knowledge spillovers occur because 'geographical regions with greater amounts of knowledge-generating inputs, measured by using patent counts, produce more innovation.'

One mechanism of knowledge transfer that Owen-Smith & Powell (2004:6) mention that advances knowledge spillovers (i.e. where knowledge is shared formally and informally) is that of joint authorship. This issue will not be discussed in detail in this dissertation; suffice to say that 'if contact research means that a faculty member involved must delay publication or comply with a gag rule, so as to protect trade secrets there is no better way to diminish the free flow of knowledge and knowledge is the foundation of university research' (Lee, 1996:861).

One limitation is conceptual because there is no understanding of the way in which spillovers occur and are realized at the geographic level (Howells, 2002:876). However, 'tacit knowledge, situation and locational contexts do play a significant role in the use and spread of codified knowledge. Thus, although codified knowledge may be more ubiquitous and accessible, its interpretation and assimilation are still influenced by geography,' writes Howells (2002:876). Too few studies have a relevant bearing on South Africa in terms of knowledge spillovers between universities and industry firms, so a direct comparison cannot be done based on what literature reveals. What can be said is that 'managers need to aim to build a community sustained by a web of positive relationships and to foster the free flow of ideas across the entire organization, which will help new interpretations and fresh perspectives to come to light' (Breen, 2006:2).

2.1.6.5 Patenting is problematic

Dill & Doutriaux (in Powers, 2000:25) state that while universities have traditionally pursued licensing or royalty routes to commercialization, generally because the associated risks are lower, 'these paths are a relatively inefficient means of maximizing potential returns on a patented product.' The reason for this, write Gregory &

Sheahan as well as Sugarman (in Powers, 2000:25), is because 'patented ideas or inventions often do not become commercialized products and those that do *make it*, experience erosion over time in their value through the reinvention and obsolescence process.'

The area of patenting is specifically mentioned by South Africa's DEPARTMENT OF SCIENCE & TECHNOLOGY to be an area which needs urgent attention (DST, 2002:67). The NRDS (2002) document too, mentions that South African inventors with priority registration in the SA Patent Office secure around 100 US patents per year. This represents 2.5 patents per million of population per annum. Since patents represent (with copyright) one of the strongest forms of *intangible value*, this is evidence of a major weakness in South Africa's ability to become a knowledge economy.

2.1.7 War, terrorism and natural disasters

The second last driver of knowledge transfer addressed in this research dissertation is that of the impact of war, terrorism and natural disasters on the relationships between industry firms and universities in South Africa. The first word is given to Mayo (in Willus, 1951:11) who wrote that 'we live in proportion to our ability to respond to and correlate ourselves with our environment.' Mankind is finding it increasingly difficult to relate to a world buffeted by violence and catastrophe. Whewell (quoted by Tobias, 2005:1) coined the term *catastrophism,* which refers to the theory that 'certain geological and biological phenomena are caused by sudden and violent disturbances of nature rather than by continuous and uniform processes.' For our purposes it must be noted that according to Tobias (2005:2), 'apart from catastrophes from the geosphere (within Earth) and the cosmosphere (from outer space), it is possible also to recognise catastrophism from the biosphere (such as pandemics), from the sociosphere (urban overcrowding, high stress levels), and catastrophe from the technosphere (environmental pollution).'

Historically, the time line of our world is punctuated by wars, acts of terror and natural disasters, which vary in intensity, but have severe

impacts on people and their worlds. MacCrimmon & Wehrung (1986:3-5) state that 'hurricanes, volcanoes, and earthquakes can destroy entire communities in minutes. Malaria, smallpox, and sleeping sickness can devastate populations. In this century, technology and collective action fill our lives with man-made hazards such as nuclear war and acid rain.' Gaining control over some risks or avoiding some risks can introduce some other risks. So even apparently risk-less actions have risk associated with them due to unforeseen events or changes in perspective.

One reason for hampered knowledge transfer during natural disasters for example, is the fact that infrastructure in its totality is disrupted, persons having the skills and abilities are often killed, the scale of damage is so extensive and restoring critical aspects such as electricity complicates the matter even further. During an instance of disaster, people must be empowered to restore their lives to some semblance of normality as soon as possible.

Thus this driver of knowledge transfer (i.e. the impact of war, terrorism and natural disasters) implies the involvement of risk. Risk means that human beings or firms are exposed to the chance of injury or loss, and according to MacCrimmon & Wehrung (1986:10) there are three components of risk, namely:

- The magnitude of loss;
- The chance of loss; and
- The exposure to loss.

The problem for firms lies in the fact that decision-makers only have probabilistic knowledge upon which they have to choose a course of action (MacCrimmon & Wehrung, 1986:10), and because of the fact that mankind has little control over natural disasters it might be wise to concentrate on the issue of terrorism, which has become everyone's problem of late.

The effect of terrorism on our world, and to lesser extent incidents of terrorism in South Africa, necessitates discussing the issue as a potential driver of knowledge transfer. Separovic (2003:1) defines terrorism and suicide terrorism as follows:

- 'Terrorism is the use of terrorising methods, the state of fear and submission so produced, a method of resisting a government or of governing by deliberate acts of armed violence. Terrorism is a method of combat in which random or symbolic victims serve as an instrumental target of terror. The aim is either to immobilise them in order to produce disorientation and/or compliance, or it aims to mobilise secondary targets of demands (e.g. a government), or it targets public opinion in order to change attitude/behaviour. International terrorism is the international use of, or threat to use, violence against civilians or against civilian targets, in order to attain political aims.

- Suicide Terrorism: Co-ordinated attacks such as that of 11 September can succeed only if those carrying them out are willing to sacrifice their own lives. The suicide terrorist thus, is a typical consenting, willing victim. This kind of terrorist is driven by religious fanaticism and hatred, rather than limited political objectives and they depended on the vulnerabilities of an open and ill-prepared society.'

Modern suicide terrorism is aimed at causing devastating physical damage, which inflicts profound fear and anxiety. Its goal is to produce a negative psychological effect on an entire population rather than just victims of the actual attack; thus the terrorist's secret weapon on September the 11th was human resolve and ingenuity, rather than technological sophistication that enabled the terrorists to enter the domain of mass destruction, killing more than 5,000 people without resorting to chemical or biological weapons or improvised nuclear devices' (Separovic, 2003).

Shuja (2001:258) reasons that containment of terrorism becomes meaningless in the world of globalisation, because diseases,

weapons and people can move so freely. Pires-O'Brien (2002:152) suspects that 'the object of hate of the Al Qaeda terrorists is the liberal democracy of modern industrial society. In this sense they are united by the same hate for reason, science, technology, individualism, pluralism, tolerance, progress and freedom.' The *number* of terrorist attacks worldwide has declined, but the number of *casualties* per attack, has risen.

'September 11th marked the beginning of a new era called the *Age of Terror* and this day transformed, in a fundamental way, the thinking of people around the world about their security. In this Age of Terror, counter-terrorism will be one of the highest priorities of national governments and international institutions' *(*Separovic, 2003:4). The world needs to find a model, which will mobilise nations' scientific, technological, legal and medical expertise to battle terrorism. In this respect, South African universities and industry firms can make a contribution, for terrorism is also a moral and ethical problem. Governments need to expand surveillance in an effort to balance national security and civil liberties. Some actions proposed by Separovic (2003:4) are de-legitimization; a call for moderation; advance public understanding of political violence and ways to deal with it and countries must agree to refrain from providing 'safe harbours' for terrorists. The long-term struggle against terrorism will be largely an information war, a fight for people's minds requiring a strategic communication campaign.

In concluding the discussion of this three-fold driver to knowledge transfer it can be said that to a much milder degree South Africa has been buffeted by natural disasters, wars and terrorism, in comparison to the USA and Europe, but it still is one of the most violent countries in the world in terms of crime. Businesses and industry firms in South Africa cannot afford not to take realities of cyber-crime, destructive competitive intelligence, issues surrounding knowledge security and ethical conduct into consideration.

2.1.8 Geographic Proximity between the knowledge source and recipient

In the interface between South African universities and South African industry firms, both parties at times will be sources and recipients of knowledge. As will be seen, literature reveals that the closer the proximity between a firm and the university it is collaborating with, the greater the opportunities for rich knowledge transfer, but this only takes place when deliberate steps have been initiated to advance the transfer of knowledge between them. This is especially evident in science parks utilized for the co-location of industry and university initiatives.

Proximity between firms and universities promote the natural exchange of ideas through both formal and informal networks, reiterates Deeds et al. (2000), where '*formal methods* include licensing and cooperative alliances' (Lane & Lubatkin, 1998), while '*informal methods* include the mobility of scientists and engineers' according to Pouder & St John (in Löfsten & Lindelöf, 2005:1027).

It has been demonstrated that knowledge spills across organizations take place more readily when they are collocated (Jaffe et al., 1993; Almeida et al., 2003). What is meant by *collocation*? Geographic collocation of firms, explain Audretsch & Stephan (1996) as well as Zucker & Darby (1996a), is a function of 'access to scientific talent and the skills of *star scientists* who are active in both academic and commercial research communities.' Thus, firms who wish to advance a strategy of knowledge transfer will often invest heavily in building networks of people, who will share knowledge face-to-face, but also over the telephone, by email, and via video-conferences, as well as by way of brainstorming sessions. The contact sessions narrow geographic proximity between knowledge sources and recipients in firms and universities.

Hanson et al. (1999:108, 110) confirm that if collaborators are allowed to collectively arrive at deeper insights by going back and forth on problems they need to solve, this process can be referred to as the

logic of expert economics, because it adds the benefit of highly customized offerings. Drawing this comment through to the effect on university-industry collaborations it can be said that firms will pay for customized knowledge offerings, which provide them with the most current, detailed competitive information available at a given time.

The danger of over-investing in such person-to-person systems of knowledge transfer (Hanson et al., 1999:113) holds the risk that this may undermine a firm's value proposition – reliable systems at reasonable prices – as well as the economics of reuse. That's because their people may feel encouraged to develop a novel solution to a problem even when a perfectly good solution already exists in the knowledge repository. Furthermore, unnecessary innovations are expensive: programming and debugging new software, for instance, eats a lot of resources. Not only are the above comments reasons for caution, but one must also keep in mind that 'person-to-person knowledge sharing involves expensive travel and meeting time, those costs dilute the advantage that is created when codified knowledge is reused' stresses Hanson et al. (1999:113).

'A company's knowledge management strategy should reflect its competitive strategy: how it creates value for customers, how that value supports an economic model, and how the company's people deliver on the value and the economics' (Hanson et al., 1999:109). In collaborative agreements with universities it is of critical importance that the university has an intimate understanding of the firm's strategy, economic model and expected outputs – in order to ensure that the offerings delivered will match them as closely as possible. If not, the collaborative relationship, despite a close geographic proximity, may prove frustrating and fruitless for the firm.

2.1.9 The need to protect knowledge for competitive advantage

For the purposes of this research dissertation this will be the last driver of knowledge transfer addressed. Williams (1998:4, 13) opens the argumentation with the comment that companies such as

Microsoft, Disney and Merck, all use 'isolating mechanisms to block competition and these barriers are based on one-of-a-kind advantages such as geography, copyrights, patents, or ownership of an information resource.'

In order to make business decisions Williams (1998:13) makes use of the fighter pilot acronym, OODA, which stands for *observe, orient, decide* and *act*. This is a fine way of summarizing the process of decision-making in a competitive business environment where 'around the alignment of markets, capabilities and strategies, *convergence* and *renewal* takes place.' *Convergence* writes Williams (1998:13) implies that 'strategizing firms must realise that nothing lasts forever: success or failure.' Strategizing, decision-makers are also '*genetic engineers* and the strategy of the firm can be thought of as the *organizational DNS*, or the *genetic blueprint*, which determines the firm's growth, its shape, its life span, and what resources it must consume, and in which environment it must exist in order to sustain itself' (Williams, 1998:119). *Renewal,* explains Williams, reflects how well a company's growth engine capitalizes the resources available to it and transforms its capabilities into value. This scenario sketched by Williams requires options-rich thinking.

The imperative to protect knowledge is confirmed by Etzkowitz et al. (2000:313-314) when they indicate that identifying, creating and commercializing intellectual property has become an institutional objective in various academic systems. This imperative is brought to fruition partly through technological innovation, which provides an impetus for economic prosperity; and it includes the creation, diffusion, transformation, application and use of new ideas, methods, practices, processes, products, services, systems and technology, to generate economic growth, wealth, prosperity and wellbeing' (Amadi-Echendu, 2005:2). In the knowledge economy science is exerting a more important and direct influence on innovation, especially in fast-growing new industries (OECD, 2002:7). The intensity and quality of industry-science relationships thus play an increasing role in determining a return-on-investment in research, in terms of

competitiveness, growth, job creation and quality of life. This also determines the ability of countries to attract or retain increasingly mobile qualified labour.

2.1.9.1 Inventive activity

'It is leading edge science that delivers radical innovations' states Von Krogh et al. (2001:433, 435) and for this reason these authors write that strategizing in the knowledge economy is about 'moving away from *driving ahead by looking in the rear-view mirror* to *driving ahead by knowing what is around the corner."* What this implies is focused creativity and liberating rigour, which will impact upon the future prosperity and survivability of most business organizations (Von Krogh et al., 2001:436). It seems that inventive activity is, to a considerable degree, a function of unique supply-and-demand conditions that prevail in many industry sectors and depend to a large extent on the resources a firm can deploy to invest in inventions.

2.1.9.2 The goal of a competitive strategy

What is the goal of a competitive strategy? Porter (1980:3-4) is of the opinion that 'a competitive strategy helps a firm to find a position in the industry where the company can best defend itself against competitive forces (entry, threats of substitution, bargaining power of buyers, bargaining power of suppliers, and rivalry among existing competitors) or can influence them in its favour.' To Von Krogh & Roos (1995:57) a sound competitive strategy involves 'the discovery of potential sources of knowledge in the organization, as well as a thematization of the competitively superior knowledge that needs to be nurtured in the future time-frame.'

What then is one serious threat to competitive advantage? In the opinion of Reed & DeFillippi (1990:88) and Barney (1991:99), it is *imitation*. Literature reveals that causal ambiguity is a determinant of imitation. Reed & DeFillippi (1990:89,91) suggest that *causal ambiguity* is the main determinant of imitation, and as such these

authors explain that it should be defined in terms of 'tacitness, complexity and specificity,' where:

- *Tacitness* refers to the implicit and non-codifiable accumulation of skills that result from learning by doing. Tacitness is embodied within the skill component of competences;
- *Complexity* results from having a large number of interdependent skills and assets; and where
- *Specificity* refers to the transaction-specific skills and assets that are utilized in the production processes and provision of service to particular customers.

This being the case, how can firms address some of these issues in order to retain their competitive advantages? One answer is in strategic alliances with existing or potential competitors, which might provide new knowledge about their strategies, technologies and personal resources, thereby enhancing the internal capability to predict their future strategic moves (Von Krogh et al., 2001:433). In some instances this might be hard to do, but at the same time firms need to scan their knowledge environments and take note of factors such as their size, past experiences, their research and knowledge capacity and location, in relation to their competitors (Howells, 2002:878). Competitive advantage is at the heart of a firm's performance in competitive markets, reiterates Porter (1985: xv-xvi), as it grows fundamentally out of the value a firm is able to create for its buyers. But competitive advantage can also be created by the size of a firm, its access to resources or even by plain good luck, reiterates Von Krogh & Roos (1995:56).

2.1.9.3 Consumerable R&D in a competitive environment

The fact that the competitive landscape today is characterised by the simultaneous effect of rapid-fire technological change, shorter product life cycles, the continual entrance of new players, and constantly evolving customer needs, cannot be debated. To combat these

multiple forces, firms must have access to a wellspring of new competitive technologies (Werther, Berman & Vasconcellos, 1994; Santoro & Gopalakrishnan, 2001:163). This said, Von Krogh & Roos (1995:65) add to this point by saying that the process of '*legitimization* is needed for the firm to prevent an individual's stock of knowledge from disturbing the continuity and regularity of its operation,' and legitimization also provides 'a context in which to convey knowledge' (Berger & Luckman, 1967). Robey & Markus (1998:8) argue that practitioners can make research consumable in the manner in which they undertake, present, disseminate and evaluate research. These authors declare that *consumable research* can and should be both 'rigorous and relevant.'

2.1.9.4 Knowledge Domains

The use of information in decision-making, especially formal market research information is often a complex process involving many people and organizational units (Moorman, Zaltman & Deshpande, 1992:314-5). This is not surprising to Barabba & Zaltman (1991), who ascribe this to a variety of factors which affect the process, many of which are behavioural rather than technical. The reality is that 'we are drowning in information and starving for knowledge' (Naisbett, 1984), and decision makers are further challenged by problems of volume and sophistication in various knowledge domains, which are exacerbated by a growing variety of functional area customers of market research. To compound the problem Moorman, Zaltman & Deshpande (1992:315) add that more and more firms are relying on 'external research organizations rather than internal staff to trim operating expenses' and the result is often shorter term relationships with researchers who lack experience with the firm, and perhaps are not privy to information that could assist in creating and using research in more effective ways.

Von Krogh et al. (2001:422) believe in the role of knowledge as a key differentiator and for that reason they motivate that firms should get a better grasp on the term *knowledge domain*. 'A knowledge domain

consists of relevant data, information, articulated knowledge (such as handbooks, manuals or presentations), and a list of key people and groups with tacit knowledge based on long-term work experiences' (Von Krogh et al., 2001:423). These authors go on to say that the purpose of these communities is to act as 'custodian for the knowledge domain,' nurturing the sharing and creation of practices and knowledge that is key to the achievement of both company and personal objectives. These authors elaborate further by adding that another purpose of a knowledge community is to ensure that the professionals collaborate across plants, geographical boundaries, and sometimes also functional boundaries. More authors share this opinion, such as Bloedon & Stokes (1994:44) who say that universities are recognised as suppliers of talent for companies and universities are well-positioned to develop as a prime knowledge and research supplier for companies.

If one views knowledge as inherently fluid, social and evolving through practice (Von Krogh et al., 2001:436), then the challenge lies in getting the knowledge domains to work as vibrant, energetic, creative, social arenas, where managers need to enable rather than control knowledge creation and transfer processes. The decisions managers make in terms of the firm's knowledge strategy are therefore quite important.

A firm's Knowledge Strategy, in the view of Von Krogh et al. (2001:435) includes the allocation of resources to knowledge creation and transfer for the sake of developing existing and new knowledge domains. The four strategies these authors developed are:

- Leveraging existing knowledge throughout the company;
- Expanding on existing knowledge within the company;
- Appropriating new knowledge from outside the company to build up a new knowledge domain; and finally
- Probing new knowledge within the company.

It cannot be denied that in the global village today there is an *insatiable market for knowledge* and the most visible transformation is the emergence of broad alliances between universities and firms, and growing activity in the realm of commercialization of results through licensing of intellectual property and spin-off companies (OECD, 2002:7). Thus, in the knowledge economy a key source of sustainable competitive advantage and superior profitability within an industry (Von Krogh et al., 2001:421) 'is how a company creates and shares its knowledge.'

In their article Argote & Ingram (2000:150) state that the creation and transfer of knowledge is a basis for competitive advantage, because multiple *knowledge reservoirs* (i.e. repositories where knowledge is embedded in organizations) exist in firms (Levitt & March, 1988; Starbuck, 1992; Walsh & Ungson, 1991). The French word *reservoir* means to keep for future use and this implies that knowledge can be re-used in various contexts and in different ways at a later stage.

2.1.9.5 Knowledge creation, power, transferability, decay and loss in terms of competitive advantage

'The target of knowledge creation is to enhance the potential of creating innovations' (Von Krogh et al., 2001:424) and this usually entails the following steps:

- Knowledge domain members start by creating collective *tacit* knowledge by jointly experiencing new work processes, tasks, technological characteristics, use of technologies, customer sites, etc. Members must spend considerable time together, discuss and reflect upon their experiences, observe how their colleagues solve tasks and interact with technologies, while explaining and making sense of their own actions.

- In the next phase the team attempts to make these collective experiences *explicit*, through agreeing on proper, just, and accurate descriptions of their experiences, which can be used in a

brainstorming fashion to develop new product and service concepts based on their experiences.

- Then this concept comes under close scrutiny. It is matched against market data, consumer trends, and technological requirements such as the process data, cost of manufacturing the finished product, strategies, goals and so forth.

- Finally, if a concept passes successfully through to this phase it is transformed into a prototype process, product or service.

Another issue addressed by Howells (2002:881) is that of the *power dimension*. As with all relationships, the process of transferring and utilizing knowledge is shaped by issues of asymmetries in power, both in relation to socially bonded knowledge and in terms of inter-firm and inter-organizational knowledge relationships (Harvey, 1999). No-one will deny the relevance of power residing in firms and individuals with competitive knowledge, but knowledge of who knows what in a particular industry can give one the edge, so it is critical knowledge to have.

In terms of the transferability of knowledge Howells (2002:880) mentions that because 'many firms in peripheral regions have low absorptive capabilities, their ability to benefit from external knowledge remains limited.' However, sometimes the knowledge remains too complex and tacit to be absorbed – however hard a firm tries. Time, decay and loss are other crucial elements in knowledge transfer, which can affect competitive advantage. The value and utility of knowledge can decay over time, but it can also be lost or simply forgotten. Yet, the decay of knowledge can be equally important in influencing the geography of innovation and growth. Managers must therefore make a rational decision about the value and utility of all types of knowledge in the firm and what to do with dated information, which can clutter up systems.

2.1.9.6 The critical role of trust

In their research Moorman, Zaltman & Deshpande (1992:314), using 779 users and providers of market research information, have investigated the role of trust between users of R&D knowledge and knowledge providers; they say that currently 'there are few technological reasons, which prevent companies from obtaining timely, valid and reliable information, which will be relevant to most of their problems.' The issue of trust, however, plays a very important role in the relationship between buyers of R&D (i.e. industry firms) and suppliers of R&D (i.e. universities).

The concept of trust can be defined as 'a willingness to rely on an exchange partner in whom one has confidence' (Moorman et al., 1992:315). This definition implies two approaches:

(1) Trust is firstly viewed as a belief, a sentiment, or an expectation about an exchange partner's trustworthiness, and this trust results from the partner's expertise, reliability, or intentionality (Blau, 1964; Rotter, 1967; Pruitt, 1981); or

(2) Trust is viewed as a behavioural intention and the behaviour reflects a reliance on a partner. Trust in this situation involves vulnerability and uncertainty on the part of the trustor (Coleman, 1990; Schlinker et al., 1973; Zand, 1972 and Griffin, 1967).

Deutsch (in Moorman et al., 1992:315) prefers to define trust as actions that increase one's vulnerability to another, and in the opinion of Coleman (1990:100), this trust includes voluntarily placing resources at the disposal of another, or transferring control over resources to another. By implication industry firms will have access to university laboratories and infrastructure, for example, and researchers within universities will be granted access rights to testing sites at the firm's premises.

Personal trust that reduces perceived uncertainty, and perceived vulnerability associated with using marketing information, is critical in the relationship between universities and industry firms (Moorman, Zaltman & Deshpande, 1992:315). According to the great body of literature on this topic, the role of trust in relationships between universities and industry firms is influenced by, and holds, the following features:

- Trust is a determinant of relationship quality:
  - Trust is a feature of relationship quality and goes hand in hand with satisfaction and opportunism (Crosby, Evans & Cowles, 1990);
  - Trust is a feature of relationships in addition to power, communications and goal compatibility (Anderson, Lodish & Weitz, 1987);
- Trust is a determinant of the amount of cooperation and functionality of conflict between parties (Moorman, Zaltman & Deshpande, 1992:315, 322; Anderson & Weitz, 1990; Anderson & Narus, 1990);
- Trust implies a certain commitment to the relationship that goes together with a desire to maintain a valued relationship, i.e. an enduring and positive relational continuity (Dwyer, Schurr & Oh, 1987);
- Trustworthiness together with believability and honesty form part of credibility and this determines the perception of service quality (Parasuraman, Zeithaml & Berry, 1985);
- Trust plays a role in researcher involvement, i.e. the extent to which users in industry involve researchers in universities in the design, production and use of market research information (Moorman et al., 1992:316);

- Trust affects the perceived quality of interactions as being productive (Moorman et al., 1992:316);
- Trust should heighten the quality of interactions as users share more comprehensive, accurate, and timely information about their research needs and as industry firms provide more background information to researchers (Bialaszewski & Giallourakis, 1985; Dwyer et al., 1987; Schurr & Ozanne, 1985; Zand, 1972);
- Trust enables both parties to find productive resolutions to disagreements that might occur between the parties (Moorman, Zaltman & Deshpande, 1992:316);
- Trust affects the manner and level or extent of research utilization, i.e. the extent to which the research influences the user's decision-making, because deepened investments increase research quality and the degree to which the knowledge which is transferred, is actionable, timely, and comprehensive (Moorman et al., 1992:316; Bailey & Pearson, 1983; and Deshpande & Zaltman, 1982);
- Trust levels can increase the believability of market research (Holzner & Marx, 1979);
- In the opinion of Moorman, Zaltman & Deshpande (1992:316) the greater the trust users have in researchers:
    - The greater the researcher involvement in the research process;
    - The higher users perceive the quality of their intentions with researchers to be;
    - The more committed users are to their relationships with researchers; and
    - The greater users' utilization of market research information.

In view of the drivers of knowledge transfer it would be helpful to gain deeper clarity on what potential benefits are to be gleaned from R&D collaborations with industry firms for researchers and their universities. Greater researcher involvement in the industry firm's research process according to Moorman, Zaltman & Deshpande (1992:317), can include the following:

- The development of marketing strategy recommendations;
- Assisting in the implementation of such recommendations;
- Gaining knowledge and experience of the firms environment;
- Becoming more customer orientated and less technical orientated;
- Ideas should reflect a sounder strategic understanding of the firm;
- Higher quality interactions and greater levels of researcher involvement;
- Such sharing improves a researcher's ability to design and disseminate research that is relevant to users and firms will be more likely to apply and utilize such market research information in their decision-making process;
- Users and providers of knowledge within the same firm (intra-organizational) have a common basis for communicating and resolving conflicts; such firms are more likely to have fewer organizational differences, write Moorman, Zaltman & Deshpande (1992:318), because of their shared assumptions, expectations and decision rules;
- Inter-organizational firms on the other hand have more tenuous collaborative relationships and the quality of interactions may be poorer because parties are less willing to share proprietary information; they meet less often;

discussions are often more formal; there is less opportunity for productive disagreements and the type of informal give-and-take that often generates new ideas, is largely absent (Moorman et al., 1992:318);

- The rate of information diffusion and knowledge transfer is greatest when the adopter (in this case the industry partner who is a buyer of R&D knowledge), and the change agent (in this case the university or provider of knowledge), are somewhat different from one another, stresses Roger (in Moorman, Zaltman & Deshpande, 1992:323);

- Increased involvement and commitment may decrease, according to Austin (1991:6), because high levels of risk and vulnerability create opportunities for distrust or opportunistic behaviour; this in turn may reduce a researcher's incentive to perform and results in a lack of consistency in the researcher's behaviour over the life of the relationship.

2.1.9.7 Resource Allocation in competitive advantage

In the resource-based approach to business, the firm is seen as a *portfolio of resources (*Rummelt, 1974:557) and this approach implies that a firm's competitive position is defined by 'a bundle of unique resources and relationships.' This being the case, Rummelt (citing Barney, 1974:791) writes that the critical task of a firm firstly becomes one of 'maintaining the uniqueness of its products and services' and secondly lies in 'balancing the costs of obtaining this difference with performance.' Unique resources alone will not secure competitive advantage thus; deployment of resources must be accompanied by unique relationships between firms and universities, firms and suppliers, firms and their clients, etc.

The four characteristics of a resource-based perspective according to Rummelt (1974:557) are that a firm's resources must:

(a) Be valuable;

(b) There cannot be strategically equivalent substitutes;

(c) They must be imperfectly imitable; and

(d) They must be rare among competitors.

These four points indicate a strong competitive knowledge advantage, which, if sustainable, will not be easily lost or eroded by competitors. '*Sustainability* of a firm's competitive advantage hinges on how easy it is to replicate,' i.e. how imitable the resource (asset) is, related to the characteristics of the process by which it may be accumulated (Dietrickx & Cool, 1989:1507). The next point is how these unique resources that reside within firms, are allocated. In order to determine how resources must be allocated, Von Krogh et al. (2001:427) distinguish between four generic knowledge strategies, which they call 'leveraging, expanding, appropriating and probing.'

- **The Leveraging Strategy** sets out from existing knowledge domains (i.e. product development, manufacturing, marketing, sales, human resources, purchasing or finance) and focuses on transferring that knowledge internally throughout the organization. This is essential to consolidate activities and standardize tasks. Properly recording the lessons learned from both *successes* and *failures* is crucial. Project debriefing sessions can capture and secure *technical* and *process* learning in a structured way and the knowledge can be disseminated to other research or application projects. Sharing existing knowledge within or between knowledge domains throughout the organization will reduce the risk of overtaxing resources (Von Krogh et al., 2001:427-429).

- **The Expansion Strategy** refines what is currently known and this needs to be updated on a regular basis to ensure that the information is current and relevant (Von Krogh et al., 2001:429-430).

- **The Appropriation Strategy** is externally orientated – the key challenge is to build up a *new* knowledge domain by transferring

knowledge from external sources, such as universities. In other words the knowledge domain does not pre-exist within the firm. Appropriation can occur by means of acquisitions or strategic partnerships with selected companies, research institutions, universities or other external organizations (Von Krogh et al., 2001:431-432).

- **The Probing Strategy** occurs when teams are given the responsibility to build up a new knowledge domain from scratch, and bringing individuals with an interest in doing something new together does this. They then become *corporate revolutionaries* who create new knowledge that in turn can become imperative to the long-term performance and survival of the firm. Radical innovations, beyond mere variants of existing products, or technologies employed by competitors, will result from new data, insights, models, concepts and technologies. The probing strategy reduces exposure to knowledge deterioration risks, because it allows a more balanced portfolio of existing knowledge, alongside new knowledge enabling the company to exploit future business opportunities (Von Krogh et al., 2001:433-434).

Thus researchers and marketers need to be immersed in the lifestyle, habits and attitudes of the consumer or industry partners and need to have insights into their lifestyles, norms, their use of technology, their strong and weak social ties, habit reinforcing and habit weakening behaviour, life-changing experiences and so on, because from this knowledge, entirely new areas of knowledge can grow (Von Krogh et al., 2001:434-5). This is exactly what some of the competitive advantages are of sound knowledge management and transfer.

2.1.9.8 Practical Implementation for competitive advantage

In short, the importance of this driver of knowledge transfer, particularly for industry firms, cannot be overestimated. Some practical ways in which knowledge can be protected for competitive

advantage include knowledge workshops. Such workshops with partners from industry firms and universities as well as other stakeholders can be organized in order to bring together key experts and practitioners from around the world (Von Krogh et al., 2001:422). Such workshops must be structured and facilitated in such a way that learning and understanding are discussed and captured. Knowledge gaps can also be identified during such workshops and solving these problems increases the depth and scope of the knowledge in the domain (Von Krogh et al., 2001:423).

Joint learning and learning contexts within the firm help to create the formation of shared routines between workers, which in turn helps the sharing of knowledge and the establishment of an organizational memory (Ackerman & Halverson, 2000) and this in turn guides future interpretation of events. Moreover shared routines and patterns of working, as well as the socialization of this process, help to create important environments for learning to take place and then help to form common knowledge contexts between workers in the firm (Howells, 2000:55).

Porter & Miller (1985) make the following statement: 'sustainable competitive advantage will depend less on who *has* information and increasingly on who is able to best make *use* of that information.' This being the case it would be considered most prudent that universities take cognizance of these requirements in their proposals to industry and in the manner in which R&D results are communicated to industry partners.

Chapter one has thus painted the landscape of knowledge transfer in the South African science and technology arena with cognizance of South Africa's technology colony status. Chapter two has expounded upon what literature reveals on the drivers of knowledge transfer, with particular reference to the relationship between universities and industry firms. Chapter Three will describe the Empirical Research Design and Methodology employed in addressing the research question.

CHAPTER THREE

EMPIRICAL RESEARCH DESIGN & METHODOLOGY

In this chapter the research design and methodology employed to conduct this research in an empirical, scientific and ethical manner is described. This includes articulation of the problem statement and how the problem was studied. The objectives and the rationale for the research are also addressed.

3.1 Problem Statement

A wide gap exists in the expectations and perceptions of industry partners and universities in both directions, probably as a result of a poor understanding of the drivers of knowledge transfer in their R&D collaborations. Thus the main research question centers on the drivers of knowledge transfer between universities and industry firms.

3.1.1 Objectives

The main objective for this research is to acquire an understanding of the drivers that influence knowledge transfer between industry and universities in South Africa. These drivers should provide some reasons why industry partners approach universities for R&D and other collaborative engagements.

Having this knowledge could better equip and enable universities to make pro-active and appropriate decisions in their future industry collaborations. Optimally capturing, transfer and managing R&D and other scientific knowledge would be to the benefit of other researchers and their institutions, as well as to the benefit of industry partners in the private sector, government and other stakeholders – locally, nationally and internationally.

3.1.2 Rationale & Motivation

Both the depth and variety of South Africa's scientific and technological capacity should be exploited as a strategic resource, as it contributes to the sustainability of expertise in Higher Education Institutions. It also contributes to the retention of a competitive advantage, while furthering the implementation of government's transformational road map for the advancement of science and technology.

The results of this study can be a powerful communication and collaboration tool, as this research project is in line with the critical challenges of increasing participation and responsiveness to societal needs in a technology-oriented environment, with the purpose of improving partnerships between academic institutions, government, industry and civil society. These critical relationships add value to education, and promote and elicit funding for R&D projects, and ensure that future needs are met in all academic fields, as we broaden our horizons in the challenging R&D landscape.

This point ties in with the drive toward multi-disciplinary diffusion of knowledge and the creation of Communities of Practice and Centers of Expertise – thereby bridging the knowledge divide that exists between and Higher Education Institutions with their R&D capacity and the technological needs experienced in industries nationally and internationally.

This study will serve as an accessible platform of knowledge that will further the drive to sustain and develop the innovation generation ensuring that Higher Education Institutions remain locally relevant, yet globally competitive.

3.2 The Research Design

Members of the DEPARTMENT OF ENGINEERING & TECHNOLOGY MANAGEMENT within the Faculty of Engineering, Built Environment & Information Technology (University of Pretoria), designed the

proposed survey and gave it the title of SOUTH AFRICAN RESEARCH MARKETING & TECHNOLOGY COMMERCIALIZATION SURVEY.

In designing the survey it was decided to address the following four issues, viz:

- The gap between university delivery of R&D and industry's perception as well as the expectations of industry partners in R&D collaborations with research institutes;
- The extent of linkages between industry stakeholders and decision-makers and researchers who form part of the Research-to-Innovation Value Chain, within the South African National System of Innovation;
- The behavioural preferences required for effective Engineering and Technology Management in the South African knowledge economy in order to link to disciplinary fields which can be far removed; and
- The drivers, barriers, success factors and challenges that affect the transfer of knowledge between the entities mentioned above.

This research dissertation focuses solely on the drivers of knowledge transfer, mentioned in the last bullet. In the survey (attached as Annexure A), the last question of Section IV addresses the drivers of knowledge transfer.

3.2.1 Background information and Literature Review

The first section of this research project was devoted to a literature review. The aim was to acquire information on the National System of Innovation and the interface between Higher Education Institutions and industry. Specific references were cited that addressed the Triple Helix Model, the Research-to-Innovation Value Chain and the Technology Colony concept.

Thereafter the literature review focussed on the South African landscape of Science & Technology, and corroborating statistics were

sought. The research strategy was aimed at understanding what drives R&D collaborations between industry firms and universities and this strategy determined the structure of the research project itself.

The literature review was undertaken to synthesize what scientific literature has to say in terms of theories, models, trends, and the results of studies that address the relevant issues of this research project. This formed the basis and departure point of the research project and is an essential part of the research methodology (Mouton, 2001).

3.2.2 The Survey Design

While the foundation was being laid through the literature review and concurrent to it, the design and development of the measuring instrument, a survey, was initiated.

Several similar surveys used within the DEPARTMENT OF ENGINEERING & TECHNOLOGY MANAGEMENT, the NATIONAL RESEARCH FOUNDATION and the UNIVERSITY OF APPLIED SCIENCES in Muenster, Germany, were reviewed. A section of the South African survey formed part of a similar survey on technology marketing used by the University in Muenster, to conduct surveys in Germany, Austria, Japan and England in the last two years. Their sole focus was to examine industry satisfaction with universities in collaborative research and development activities. Inclusion of these international questions, it is hoped, will provide useful information for benchmarking purposes, i.e. it will be possible to benchmark the South African university-industry collaborations with the countries mentioned above.

'In order to collect data, some form of measuring instrument has to be used,' (Mouton, 2001:100) which will offer validity and reliability. The use of the Likert Scale was considered. The ubiquitous Likert scale (2002:40) asks respondents to 'express agreement or disagreement with a set of attitude statements using a five-point scale' and Jacoby & Matell (1971:495) write that it is often used 'in collecting attitudinal

and image data in marketing and public opinion research.' This method seemed the most viable option to capture the responses and to gauge the perception of industry partners on R&D relationships they have with universities. Further validation for this choice of measuring instrument came from Jamieson (2004:1212) as well as Blaikie (2003), Hansen (2003), Cohen, Manion & Morrison (2000) and Pett (1997), who explain that 'Likert-type rating scales are used to measure views and attitudes by providing a range of responses to a given question or statement'. Typically Likert Scales have five categories of response, as was mentioned above. In this survey industry respondents were asked to rate the drivers of knowledge transfer using a rating of significance from 1 to 5, with one being *not significant*, 2 being *vaguely significant*, 3 being *significant*, 4 being *very significant* and 5 being *extremely significant*.

It is important to note that this sample is a convenience or judgemental, non-random sample of companies in South Africa. The survey is wide ranging and was designed to address various factors, among them the drivers of knowledge transfer between universities and their industrial partners in R&D collaborations.

3.2.3 Distribution of the Survey

The RESEARCH MARKETING & TECHNOLOGY COMMERCIALIZATION SURVEY was used as the chosen instrument to gather responses from companies targeted in South Africa, which were selected on the basis of prior R&D contracts with universities.

It was decided to distribute the survey via an email together with a covering letter. The survey was attached as a PDF file. Assurance was given that responses would be treated with the highest confidentiality. Completed surveys could be returned either via email, fax or by post. Care was taken with the design, pilot testing and distribution of the survey to ensure reasonable results.

3.3 Research Methodology

3.3.1 Preparatory Fieldwork

Firms that have current R&D collaborations with universities, or have had in the past, were selected to participate in the survey. The identified firms were selected to include the following industry sectors:

- Agriculture, forestry and fishing;
- Mining and Minerals Processing;
- Finance, Insurance & Real Estate;
- Retail Trade;
- Construction;
- Resources;
- Manufacturing;
- Transport and Public Utilities;
- Public Administration;
- Wholesale Trade; and
- Services.

At this point a first contact telephone call was made to the initial industry firms identified as possible respondents. The purpose thereof was to confirm reliable contact details of either their R&D Manager, or their CEO/MD or their Technical Director, thus successful contacts were established.

The study team comprising the author and supervisors then selected a pilot organizations in order to test the survey instrument. The pilot study participants were requested to critically evaluate the survey in its totality and to then complete the survey. Whilst doing so they were asked to explain how they interpreted the items in the survey and

comment on issues such as better wording, ambiguity, layout, logic and coherency. This exercise was considered necessary to establish and enhance the face validity of the questions in the survey and to validate each question in the four sections. These recommendations were incorporated in the survey.

A final draft of the survey was then submitted to the *Research Ethics Committee* of the FACULTY OF ENGINEERING, BUILT ENVIRONMENT & INFORMATION TECHNOLOGY at the University of Pretoria, for approval.

3.3.2 The Research Area

The research area is defined as South African science and technology industries, which have in the past, or are currently engaged in collaborative R&D projects with Higher Education Institutions.

3.3.3 Progressive Work Plan

It was necessary to adapt the work plan during the research process to accommodate the poor response rate. Data collection needed to be completed by December 2005, but due to the poor response of industry firms, another concentrated effort was launched in November 2005. Reminder emails were sent to all the firms, which had not yet responded.

The names of additional firms were obtained via referrals, intelligence gathering, and prospecting among South Africa's top 100 companies, as well as from the Internet business information provider, KOMPASS REEDBASE (http://www.kompass.com) in order to compliment the sample frame. A few firms, which had contracted Higher Education Institutions for R&D and had received THRIP grants from the NATIONAL RESEARCH FOUNDATION in 2004-5, were also approached to participate.

In total 211 industry firms received the survey and were requested to participate. Despite the considerable effort, the response rate for this second round was even poorer – a mere four surveys were returned.

Following a slight modification for data capturing purposes, the new version of the survey was sent out again in February 2006 to all the firms who had not yet responded. The final due date for responses was set for 31 March 2006. At that time 69 of the possible 211 surveys were returned.

Upon telephone inquiry, several firms declined to participate without supplying reasons, and many more did not reply after the initial contact, survey dispatch and subsequent follow-up calls. The responses for non-participation included the following reasons:

No of Firms	Reasons for non-participation
17	Declined participation, because they did not engage in any R&D efforts.
9	Deferred because participation interfered with their *core business* activities.
19	Declined due to time constraints.
3	Their firm's confidentiality policy disallows them to participate.
5	Were afraid that confidential information was required and had just thrown the surveys away.
4	Indicated that their offices did not handle the R&D function any longer.
85	Did not participate and did not give reasons for non-participation

Table 8: Reasons for non-participation in survey

Thus of the 211 firms targeted a mere 69 responded and these responses were set aside for analysis. Of these 69 respondents, 13 were from the agricultural sector, 10 from mining industries, 3 from finance, 1 in retail, 2 in construction, 17 in manufacturing, 3 in transport, 2 in public administration and 18 in the service industry sector.

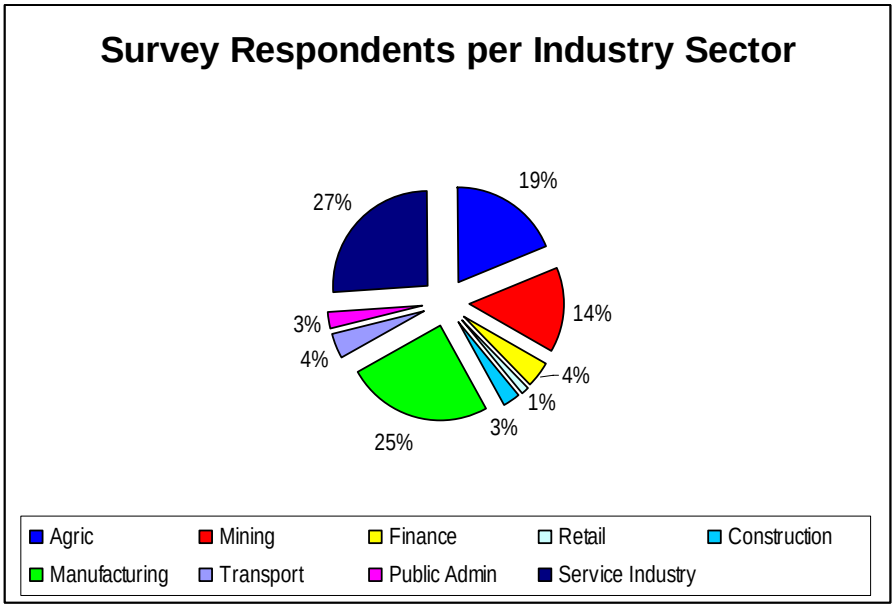


Figure 6: Survey respondents per industry sector

3.3.4 Evaluation of Results

The 69 surveys received were evaluated visually to ascertain that all the pages of the survey were intact, legible and had been completed by the respondents. In order to ensure that the data was clean, an iterative process was initiated whereby if it became evident that a respondent might have misinterpreted an answer, he/she was telephoned to clarify the issue and to fax back the question once it had been correctly completed. Several respondents had declined to answer certain sections or certain questions. Follow-up telephone calls were also made to these respondents to ensure that there were valid reasons for neglecting to complete these questions.

The surveys were then handed in at the DEPARTMENT OF STATISTICS, where the data was captured. The SAS Version 8.2 program used does an automated checking and cleaning process whereby programmed discrepancy checks are run on the data. A formal printout was received from the DEPARTMENT OF STATISTICS. A thorough evaluation of the results of the survey commenced with particular attention to the last question in the survey that of the drivers of knowledge transfer, as this is the focus of this dissertation.

3.3.5 Analysis of Results

Chapter Three has described the empirical research design and methodology employed. In Chapter Four the data collected will be evaluated and the preliminary findings will be discussed. Pie charts are used to indicate how industry partners have voted on the significance of each of the nine drivers of knowledge transfer.

CHAPTER FOUR

DATA COLLECTION & PRELIMINARY FINDINGS

In this chapter the preliminary findings and frequency distributions based on the data gathered via the RESEARCH MARKETING & TECHNOLOGY COMMERCIALIZATION SURVEY, will be presented. It is important to note that this sample is a convenience or judgemental, non-random sample of companies in South Africa. The survey is wide ranging and was designed to address various factors, among them the drivers of knowledge transfer between universities and their industrial partners in R&D collaborations. The findings upon which this research project are based, comprises data from feedback received from 69 respondents as at 31 March 2006. The viewpoint is that of industry as buyers of university R&D services.

The research focus thus lies with the following drivers of knowledge transfer (extracted from Cummings & Teng, 2003:54):

(a) The perception of knowledge as a valuable resource;

(b) Emphasis on return-on-investment in research;

(c) The need to close the knowledge gap;

(d) The need to extract appropriate knowledge at the right time to make critical decisions;

(e) The impact of International Trade;

(f) Intellectual property protection;

(g) The impact of war, terrorism and natural disasters;

(h) The role of geographic proximity between the knowledge source and recipient; and lastly

(i) The need to protect knowledge for competitive advantage.

4.1 Respondent Profile

The 69 respondents to the RESEARCH MARKETING & TECHNOLOGY COMMERCIALIZATION SURVEY are categorized according to their industry sectors in Table 9 below.

Industry Sector	Number of respondents
Agriculture	13
Mining	10
Finance	3
Retail	1
Construction	2
Manufacturing	17
Transport	3
Public Administration	2
Service	18

Table 9: Profile of respondents according to industry sector

4.2 Respondent Feedback

4.2.1 Perception of knowledge as a valuable resource

An overwhelming number of respondents to the above-mentioned survey show that they rate this driver of knowledge transfer to be extremely significant. 46% of the industry partners rate this driver as extremely significant, while a further 34% rated it as a very significant and valuable resource.

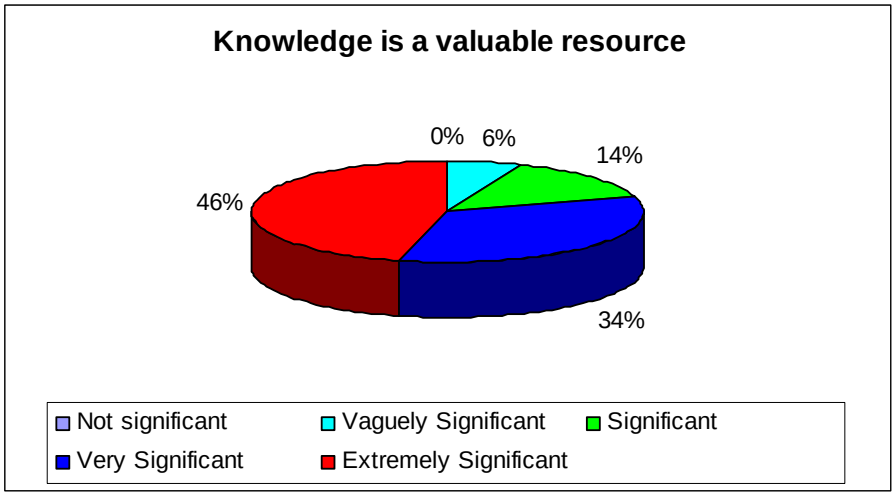


Figure 7: Respondent votes on the perception that knowledge is a valuable resource

As illustrated in Figure 7, 80% of South African survey respondents have indicated that knowledge is perceived as a very valuable resource. This finding is in line with statements made by Blumentritt & Johnston (1999:287) who acknowledge that 'knowledge is a key intangible asset, but that an isolated piece of knowledge, statement, or theory, is quite literally useless, indeed has no meaning, unless it is embedded in a supporting context of well-developed theory, evidence, and argument,' thus establishing the necessary interpretive context of theory, concepts, data and tacit experience is vital.

4.2.2 Emphasis on return-on-investment in research

Rosenberg (1990) has argued that 'industry has no compulsion to advance the frontiers of science, they are merely lured by the possibility of a high payoff and/or royalties.' Siegal et al (1999) agrees that industry only funds research if the firm can validate the potential for commercialization. It is therefore no surprise to note in Figure 8 below that over 70% of respondents to the survey also regard getting a return-on-investment to be an important driver for knowledge transfer in their R&D collaborations.

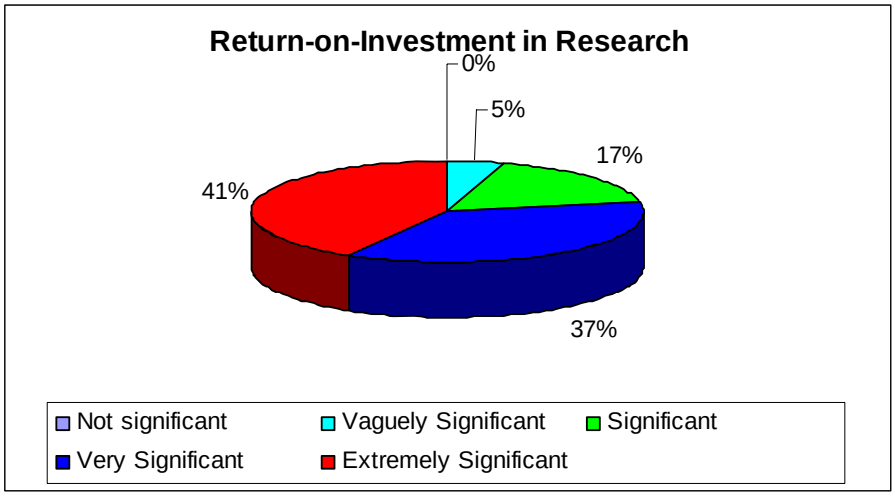


Figure 8: Respondent votes on emphasis on getting a return-on-investment in research

In Figure 8 the finding of this driver of knowledge transfer is portrayed. 11 of the 69 respondents said that return-on-investment is significant in their firm, 24 said it was very significant and 27 rated it as extremely significant. This finding raises the stakes substantially in terms of determining which projects are most likely to receive industry funding. Thus universities will have to ensure that their R&D proposals articulate the likely benefits that industry will derive from such collaborations.

4.2.3 The need to close the knowledge gap

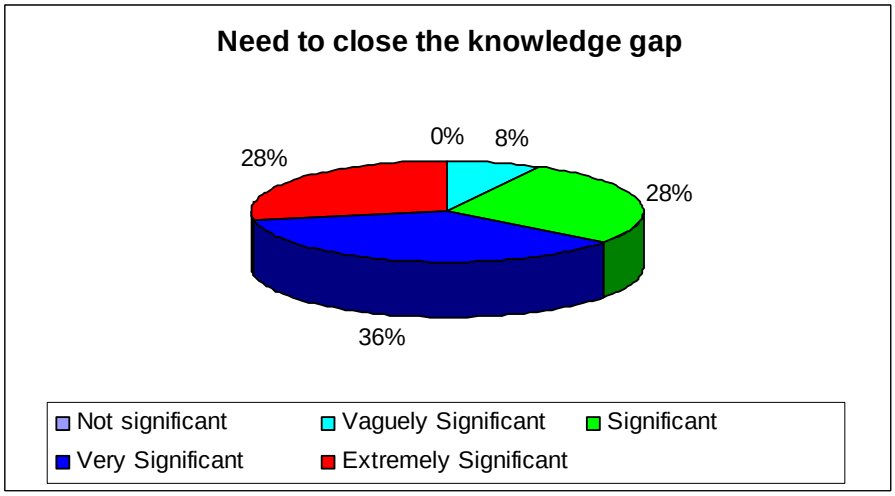


Figure 9: Respondent votes on the need to close the knowledge gap

In South Africa, closing the knowledge gap between universities and industry firms has to incorporate the challenge of bridging the gap between those who have critical R&D information and the ability to interpret and use it, and those who do not and need access to such information. Thus, it is not surprising that 60 of the 69 respondents from industry indicate that the need to close the knowledge gap is significant, to extremely significant, as a driver of knowledge transfer.

The rating given by 28% of industry partners that closing the knowledge gap between themselves and universities is extremely significant and another 35% of firms saying that this driver is very significant, may reveal the apprehensiveness about the ever-widening gap between what is known, and how it is applied or exploited. Etzkowitz (2000) suggests cross-internships between university and industry as one way to reduce the knowledge gap. Another is to provide opportunities for firms and university representative to hold regular workshops and discussion forums as is done regularly at THE INNOVATION HUB.

4.2.4 The need to extract appropriate knowledge to make good decisions

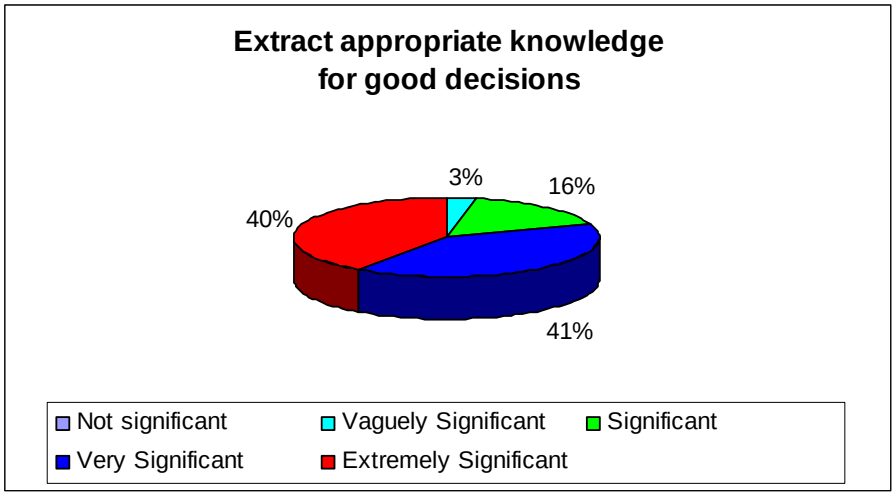


Figure 10: Respondent votes on the need to extract appropriate knowledge to make good decisions

In Figure 10, 27 of the 69 overall respondents indicate that being able to extract appropriate information is an extremely significant driver of knowledge transfer. If 41% rate this factor as extremely significant and another 40% rate it as very significant, it is obvious that the greatest number of industry respondents consider this issue to be important.

These observations are no surprise, because all decision-making depends on appropriate instructive and descriptive information or knowledge, which is unambiguous, contextualized and received in time. This finding is borne out by Yu (2002) who stresses the need for 'speed of information provision,' and by Shrivastava (in Kazanjian et al, 2000) who indicates that 'knowledge systematization and grouping, complexity, relevance and timeliness' are critical issues in decision-making.

4.2.5 Impact of international trade

It is interesting to note in Figure 11 that only 12 of the industry respondents have indicated international trade as an extremely significant driver of knowledge transfer between universities and industry, with 20 rating it as very significant and 17 as significant. Frankly, there was an expectation that more respondents would rate this driver of knowledge transfer higher than they did, especially if one recognizes that worldwide the 'form, legitimacy, sovereignty and power of the state are increasingly threatened, because of changes in the complex international links that tend to ignore social and political borders' (Bornman & Schoonraad, 2001).

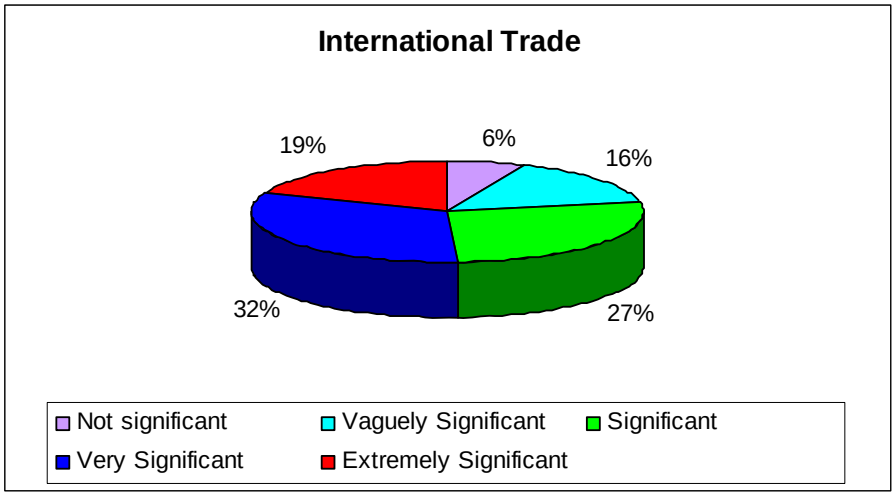


Figure 11: Respondent votes on the impact of International Trade

Thus the grouping of votes on this driver of knowledge transfer seem to indicate an even spread of 19% rating international trade as extremely significant, 32% as very significant in their firms and another 27% as significant.

4.2.6 Intellectual Property Protection

Intellectual assets represent one of the strongest forms of intangible value impacting on the knowledge and learning economy (DST, 2002).

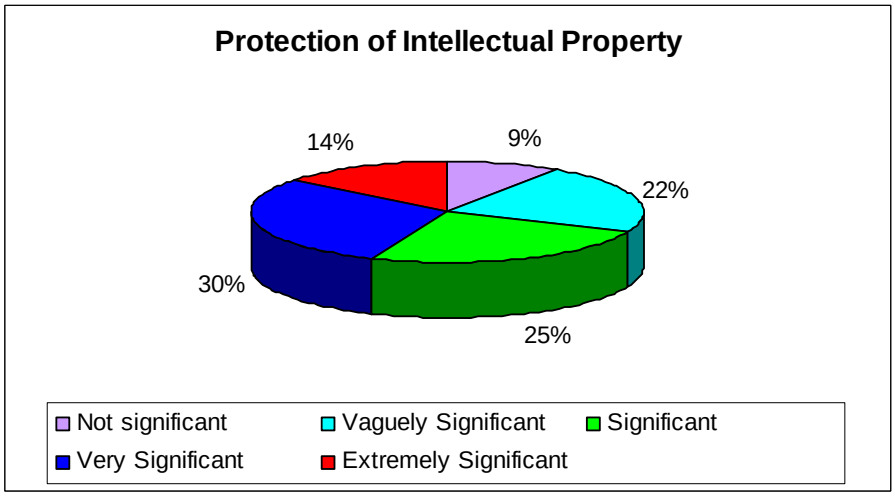


Figure 12: Respondent votes on the protection of Intellectual Property

While it is important that patents held by academics should be regarded as evidence of quality research, it does seem as though there are some academics who are unwilling, or unable, to protect and commercialize their discoveries (Etzkowitz, 2000).

The survey findings in terms of significance of the driver of Intellectual Property protection provide the following results in Figure 12: Only 9 (or 14%) industry respondents view intellectual property protection as an extremely significant driver of knowledge transfer between themselves and universities. 19 (or 30%) respondents indicate that Intellectual Property protection is very significant and a further 16 (or 25%) of the respondents to the survey indicate that this driver is merely significant. These low figures do not, therefore, provide a strong argument to suggest that intellectual property protection may be a highly relevant driver of knowledge transfer in the interface between industry and universities in South Africa.

4.2.7 The impact of war, terrorism and natural disasters

Wars, natural disasters and acts of terrorism are powerful events that should act as drivers of knowledge transfer between industry and universities on R&D collaboration; however only 21% of respondents consider this driver to be extremely significant, with a further 16% indicating that the impact of war, terrorism, and natural disasters is very significant. The interesting finding in South Africa is that overall the rating of this driver of knowledge transfer lies mostly in the lower percentile of significance. It is surprising to note that 21% of the respondents consider these issues to be of no significance at all. Should ‘crime’ have been included in this driver of knowledge transfer, it is suspected that this figure would differ dramatically as a driver of knowledge transfer.

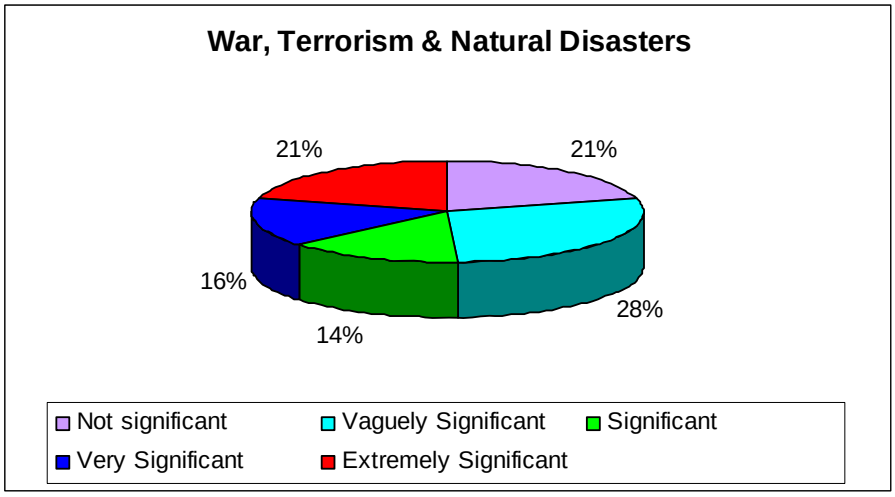


Figure 13: Respondent notes on the impact of war, terrorism and natural disasters

4.2.8 Geographic proximity between knowledge source and recipient

Proximity between industry firms and universities promotes the natural exchange of ideas through formal (i.e. cooperative alliances) and informal networks, i.e. the mobility of scientists in research institutions and engineers in industry (Löfsten & Lindelöf, 2005). This in turn increases localized knowledge spillovers (Almeida & Kogut, 1999; Almeida et al, 2003; Zucker & Darby, 1996a).

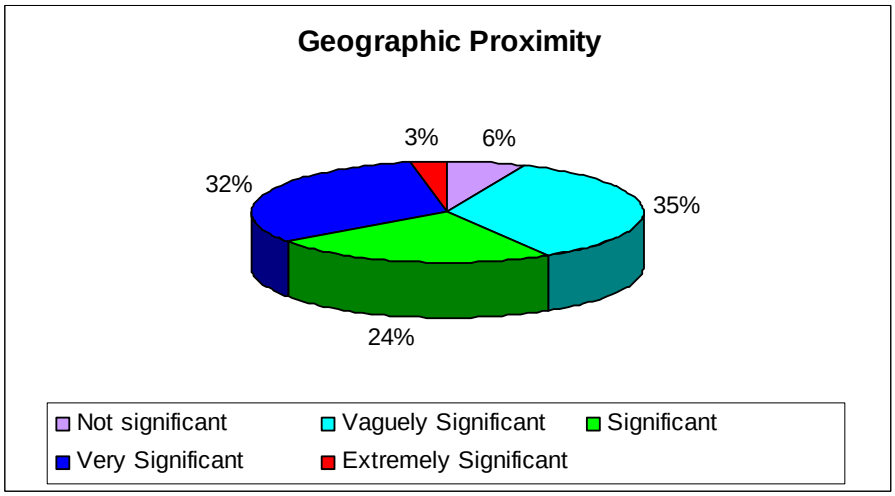


Figure 14: Respondent votes on the geographic proximity between knowledge source and recipient

One reasons for this finding in Figure 14 may be traced to Hanson et al (1999) who found that knowledge transfer is most effective if 'networks of people from universities and industry share knowledge face-to-face, over the telephone, by email, and via video conferences,' because by doing so they are able to collectively arrive at deeper insights on problems they need to solve. Advanced ICT technologies facilitate remote exchange between knowledge sources in universities and recipients in industry. Thus it is not surprising that data obtained shows that only 3% of industry respondents rate geographic proximity as extremely significant. 32% rate this driver as very significant, 24% as significant and 35% of industry partner's rate geographic proximity between themselves and their collaborators within universities as vaguely significant.

Bower (in Löfsten & Lindelöf, 2005) observes that greater flexibility is needed if universities want to encourage links with industry to advance new technologies. Some factors affected by geographic proximity according to Hislop (2003) are:

(a) The type of knowledge involved;

(b) The characteristics of the knowledge;

(c) The location of the knowledge; and

(d) How dispersed the required knowledge is.

4.2.9 The need to protect knowledge for competitive advantage

In the competitive environment firms must have access to a wellspring of new technologies and actionable knowledge (Werther et al, 1994; Santoro & Gopalakrishnan, 2001); the reason being that knowledge enables organizational renewal and sustainable competitive advantage (Inkpen, 1996). This being the case, the respondents from South Africa concur with worldwide trends of protecting knowledge assets for competitive advantage: In Figure 15 it can be noted that 40% or 26 of the 69 respondents feel that this

issue is an extremely significant driver of knowledge transfer and another 29% of respondents rate it as very significant, while 20% give this driver a rating of *significant* and a further 11% have indicated that this driver is *vaguely significant*. One possible reason for this finding may be that confidentiality clauses in contracts protect the knowledge domain and prevents disclosure of know-how to competitors without prior consent. This gives a firm a relative advantage over competitors.

It is, however, evident that alliances with universities do provide firms with a window on their partners broad capabilities and multiple knowledge reservoirs (Argote & Ingram, 2000) and collaboration allows firms to share the risks, to build on shared capabilities and to create synergies for better competitiveness (Santoro & Gopalakrishnan, 2001).

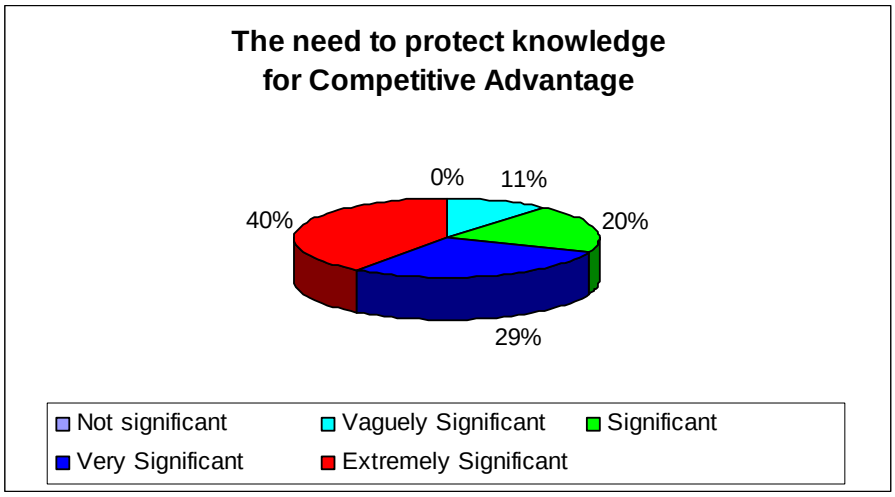


Figure 15: Respondent votes on the need to protect knowledge for competitive advantage

Thus, what is important in R&D collaborations between firms and universities is that business managers in firms need to know most about a technology when it is *new* (Robey & Markus, 1998:8,12). Novel findings appeal to practitioners, because they are things that neither they nor anyone else already knows. This is the kind of information firms want because it gives them a competitive

advantage. Universities must take cognisance of this and be pro-active in terms of communicating new knowledge.

This concludes the findings of the individual drivers of knowledge transfer between firms and their counterparts within universities.

The chart in Figure 12 below provides a summary of the respondent voting for all nine drivers of knowledge transfer:

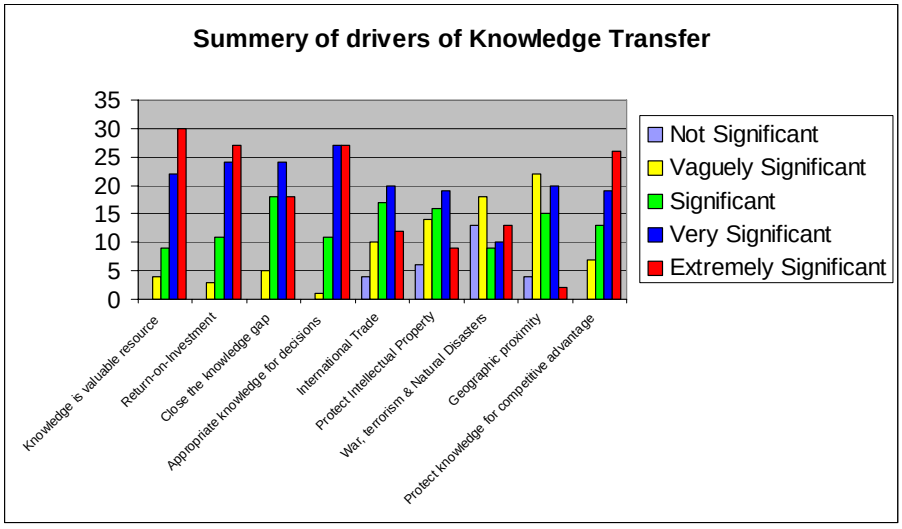


Figure 16: Respondent Votes on the Drivers of Knowledge Transfer between industry and universities

The following table indicates how industry respondents have rated the significance of the nine drivers of knowledge transfer in the breakdown offered in the survey itself.

Driver of Knowledge Transfer	Extremely Significant	Very Significant	Significant	Vaguely Significant	Not Significant
Knowledge as a valuable resource	46%	34%	14%	6%	0%
Return-on-investment	41%	37%	17%	5%	0%
Need to close the knowledge gap	28%	36%	28%	8%	0%
Appropriate knowledge to make decisions	40%	41%	16%	3%	0%
International Trade	19%	32%	27%	16%	6%
Protect Intellectual Property	14%	30%	25%	22%	9%
War, terrorism and natural disasters	21%	16%	14%	28%	21%
Geographic Proximity	3%	32%	24%	35%	6%
The need to protect knowledge for competitive advantage	40%	29%	20%	11%	0%

Table 10: Summary of industry respondents rating of the drivers of knowledge transfer

The figures incorporated in Table 10 provide a visual summary of how industry respondents have rated the 9 drivers of knowledge transfer. From these figures the following is evident:

- The following 4 drivers have the highest significance rating: Perception that knowledge is a valuable resource (46%), Return-on-investment (41%), the need to extract appropriate knowledge in order to make good decisions (40%), and finally the need to close the knowledge gap (40%).

- Of the nine drivers measured, 5 had no respondents which said that that particular driver had no significance whatsoever. The five drivers are those of perceiving knowledge to be a valuable resource, getting a return-on-investment, the need to close the knowledge gap, acquiring appropriate knowledge to make good decisions and the need to protect knowledge for competitive advantage. In these drivers the highest percentile of respondents have rated these drivers between significant and extremely significant indicating that there is a measure of consensus amongst them that these drivers play an important role in all their industries.

- The dispersion of respondents is widest on the driver of war, terrorism and natural disasters, with 21% rating this driver as extremely significant, 16% rating it as very significant, 14% rating it as significant, 29% rating it as vaguely significant and 21% say this driver has no significance whatsoever.

- Interestingly enough the next grouping of drivers in terms of significance are those of the need to close the knowledge gap (28%), war, terrorism and natural disasters (21%) and lastly the protection of intellectual property (14%).

- Geographic proximity between the source and recipient of knowledge, as a driver of knowledge transfer has the following breakdown: A mere 3% of industry respondents consider this driver to be extremely significant, but 32% have rated it as

very significant, 24% as significant and a further 35% as vaguely significant.

- In consequence it deems mention that collaborations with industry firms in South Africa should take cognisance of the fact that these findings indicate that universities must be aware that because they perceive knowledge as a valuable resource and desire to attain a return on their investment in research, it is equally important to industry to be able to extract appropriate knowledge in order to make good business decisions, while protecting their knowledge for competitive advantage.

What then is the significance and ramifications of these findings for South Africa?

In the article entitled, *Alarm Bells for Education*, the Daily News (2006:6) warns that there is an incipient crisis building up in our tertiary education institutions that, unless addressed urgently, could lead to 'a country of dullards bumbling along without the necessary skills to lift it into a world-class economy.' Higher Education Institutions are, however, aware that industry motives for partnerships with Higher Education Institutions relate largely to the institution's research expertise and physical and infra-structural resources available at Higher Education Institutions (HSRC, 2003:88), but as has been demonstrated in Chapter one and two, there is substantial evidence that collaborations between universities and industry partners in South Africa is growing. These relationships can thus be expanded to provide South Africa with a sustainable and viable output in terms of commercialization on the long term.Chapter Four has evaluated the data collected and discussed these preliminary findings on the nine drivers of knowledge transfer and how industry firms have responded in their rating of significance of each.

Consequently in Chapter Five descriptive analysis will be done by including the calculation of the *mean* and *standard deviation* in order to investigate together with the rating of significance industry partners

have given each of the nine drivers of knowledge transfer. The findings are presented by incorporating text, pie charts, figures and tables for the purposes of clarity. Thereafter some concluding remarks will be made and the dissertation will end with a few suggestions on possible areas of future research.

CHAPTER FIVE

DESCRIPTIVE ANALYSIS & CONCLUDING REMARKS

Chapter four has presented the preliminary findings from the collected data, which indicated how industry respondents voted on the significance of the nine drivers of knowledge transfer. As this population was a judgemental, non-random sample of companies in South Africa, analysis in this chapter will be confined only to descriptive statistics.

To reiterate, Figure 17 below provides a summary of the nine drivers of knowledge transfer and how they were rated by industry in terms of significance (i.e. the drivers could be rated from 1-5 with one being *not significant*, 2 being *vaguely significant*, 3 being *significant*, 4 being *very significant* and 5 being *extremely significant*).

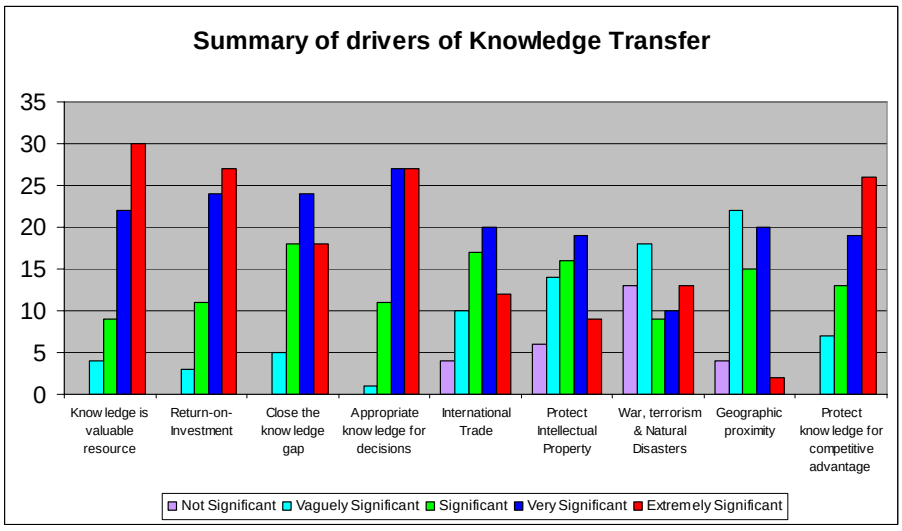


Figure 17: Summary of respondent feedback on the drivers of knowledge transfer

5.1 Descriptive Statistics

In this section particular attention will be given to the mean (i.e. significance rating) and the standard deviation (or level of agreement

with the significance rating) evident in the findings. The Department of Statistics (UP) using the S.A.S. Version 8.2 software programme (registered under SAS Co. Inc., Cary North Carolina) that runs on the mainframe of the University of Pretoria, did the calculation of the arithmetic mean and standard deviation.

In Table 11 below the nine drivers of knowledge transfer have been listed according to descending order of significance.

Drivers of Knowledge Transfer	Significance Rating (Mean)	Level of Agreement with rating (Standard Deviation)
Extract appropriate knowledge for decision-making	4.212	0.774
Knowledge is a valuable resource	4.200	0.904
Return-on-investment	4.153	0.870
Protect knowledge for competitive advantage	3.984	1.023
The need to close the knowledge gap	3.846	0.922
International Trade	3.412	1.158
Intellectual Property Protection	3.171	1.202
Geographic Proximity	2.904	1.027
War, terrorism and natural disasters	2.873	1.453

Table 11: Drivers of knowledge transfer in order of decreasing mean

By way of interpretation, the Wikipedia Encyclopaedia (2006:1) states that in statistics, the 'standard deviation is the most common measure of statistical dispersion. Simply put, standard deviation measures how spread out the values in a data set are. The closer the data values are to the mean, the lower the standard deviation (i.e. the closer to zero).' The mean and standard deviation of a set of data are usually reported together, because in a certain sense, the standard deviation is a natural measure of statistical dispersion, if the centre of the data is measured about the mean.

Lane (2006:1) states that the 'variance and the closely-related standard deviation are measures of how spread out a distribution is, while standard deviation is the square root of the variance and it is the most commonly used measure of spread.'

In the dataset in Table 11 the highest mean is 4.21 and the lowest mean is 2.87. The statistical difference between these two figures is substantial indication of strong representation for the two drivers (a) extracting knowledge for good decision-making and (b) treating knowledge as a valuable resource and protecting it as such. This concurs with the high rating given to return-on-investment with a mean of 4.15, which, as has been noted in Chapters Two (page 17-23), is of extreme importance to all industry firms who continually have their eyes on the bottom line.

Further comments, which can be made on the figures combined in Table 11 are the following:

- Industry respondents are of the opinion that the following three drivers rate the highest in terms of significance:

  (a) Extracting appropriate knowledge for decision-making (4.212 mean);

  (b) The perception that knowledge is a valuable resource (4.200 mean);

  (c) The need to get a return-on-investment in research (4.153 mean).

  Furthermore the spread or dispersion indicated by the standard deviation is very small, which is an indication that the respondents in this survey have a high level of agreement on the significance of these particular drivers.

- The following two drivers of knowledge transfer between universities and industry firms have a respective mean of 3.984 (i.e. the need to protect knowledge for competitive

advantage) and 3.846 (i.e. the need to close the knowledge gap), which have a similar rating of significance. There is, however, a greater statistical dispersion in terms of agreement, with the first driver having a standard deviation of 1.023 while the second has a standard deviation of 0.922. Thus the level of agreement on how significant these two drivers evidently are, is not as high as in the first instance.

- Table 11 indicates that the mean for the driver of *international trade* is 3.412, which is more or less the driver in the middle of the scale. What is interesting, however, is that this driver has a standard deviation of 1.158. This indicates a high level of disagreement amongst the industry partners who participated in this survey.

- The driver on the *protection of intellectual property* has a mean of 3.171 and a standard deviation of 1.202 and overall it ranks on the lower scale of significance amongst the nine drivers. Once again industry partners have not rated this driver high in terms of significance and neither is there a high level of agreement among the respondents in terms of the significance rating.

- The last two drivers of knowledge transfer, namely that of the *geographic proximity between the source and recipient of knowledge* and the driver of *war, terrorism and natural disasters*, appear last on Table 11. This indicates that according to the industry respondents these two drivers are considered by them to be of the least significance. The mean rating for geographic proximity is 2.904 and for that of war, terrorism and natural disasters is 2.873. The standard deviation for geographic proximity is substantially lower at 1.027, than the standard deviation of war, terrorism and natural disasters at 1.453. This means that more respondents agreed that geographic proximity was significant as a driver of knowledge transfer, but respondents did not agree that war,

terrorism and natural disasters was significant at all. Last named driver has the highest standard deviation figure indicating the widest statistical dispersion.

- In summary thus, industry respondents consider the first four drivers indicated in Table 11 to be the most significant and there is a high level of agreement among them that this rating is accurate.

- The following three drivers in Table 11 have a moderate level of importance, with varying dispersion rates, and the last two drivers are rated significantly lower than the previous seven in terms of significance.

In the subsequent section of chapter five corroborating evidence and concluding remarks will be made based on the figures portrayed in Table 11.

5.1.1 The need to extract knowledge for good decision-making

Today all firms in the global village can be called learning organizations (Boisot, 1995:505), because they 'position their employees along the knowledge diffusion dimension' and endeavour, through their organizational culture, to allow everyone to participate in a social learning cycle. The result is that such firms increase the opportunities to extract appropriate knowledge, which will improve decision-making.

As is evident from Table 11, industry respondents have indicated that the need to extract knowledge for decision-making provides the most significant impetus for knowledge transfer. It appears that this driver of knowledge transfer, which ranks highest in terms of significance, also has a small standard deviation of 0.774, implying that the respondents who answered this question agree that this driver is of critical importance to them. Extracting appropriate knowledge, however, does not come without pro-active efforts and the creation of optimal circumstances. Firms need to facilitate collaboration and

manage the multiplicity of agendas in their organizations (Mathiassen, 2002:339). This calls for focussed creativity channelled along 'self-reinforcing trajectories of advance which ideally should eventually become embodied in the memory and decision-making style of the organization' (Metcalfe in Dozi et al., 1988:569).

This being the case, the collaborative practices between universities and their industry partners should be organized to support diversity, but at the same time function as a shared space in which dedicated research initiatives can be formed as new opportunities emerge. To achieve this, collaboration should be organized as 'a loosely coupled system of interacting agendas' (Mathiassen, 2002:337-338).

5.1.2 Knowledge is perceived as a valuable resource

When discussing the issue of knowledge as a valuable resource in terms of its functionality in particular, 'formalized, theoretical knowledge represents one pole whereas cultural, interpersonal, somatic and other forms of tacit knowledge, together with creative skills and talents, represent the other' (Alvesson, 1993:1001, 1011). Knowledge-intensive organizations should draw upon cultural values, creativity, originality, and interactive capacities. Knowledge also plays other roles such as:

- Knowledge is a means for creating community and social identity through offering organizational members a shared language and promoting their self-esteem;
- Knowledge is a resource for persuasion;
- Knowledge provides a company with its profile (i.e. an intended image targeted at the market);
- Knowledge creates legitimacy and good faith regarding actions and outcomes; and
- Knowledge obscures uncertainty and counteracts reflection.

Knowledge cannot be produced in an unplanned fashion, however; it needs to be managed well. To Cadas (2006:64), knowledge management is an important tool that enables a company to 'react in a more positive way to different business pressures' and knowledge management enables people to be aware of who the experts are and where they are.

The perception within firms that knowledge is a valuable resource reminds one of the Mode 1 and Mode 2 knowledge production models of Gibbons et al. (1994) and Nowotny et al. (2001) where Mode 1 proposes that research practices are intended for peers and devoted to acquiring scientific legitimacy, whereas Mode 2 is characterized as follows:

- A problem-solving orientation;
- Involvement of economic actors in defining research priorities;
- Involvement of political actors in defining research priorities;
- Multiplication of research sites outside the university, because knowledge produced in the academic realm is increasingly linked to forms of application required in the economic and development sectors (Gibbons et al., 1994);
- R&D knowledge is *trans-disciplinary* rather than multi-disciplinary and the *applied context* becomes the primary locus (HSRC, 2003:2).

These points indicate some reasons why the rating of industry partners on this driver of knowledge transfer is high in terms of significance. It is worth mentioning that although perceived as a valuable resource, however, knowledge so easily can become *everything* and *nothing (*Wikström et al., 1993). Furthermore, because knowledge-intensive firms are not applying knowledge in a social vacuum, they are involved in communication, interpersonal

relations, project management, and convincing others (and themselves) about their expertise (Alvesson, 1999:1012) and universities can make significant contributions in all these areas to the benefit of all stakeholders.

5.1.3 The need to get a return-on-investment in research

This driver has been rated third in terms of significance by industry respondents and confirms a HSRC report (2003:16, 17) which emphasizes the need to ensure that research outputs and project outputs can be commercialized for the purposes of achieving the overarching goals of industry firms. In so doing this will improve the competitiveness of South African industry in the context of globalization and technological advancement. In practical terms this implies that research projects must culminate in *tangible technological advances*, and there must be a strong commitment to ensuring that knowledge does not become isolated from national human resource and SET objectives.

There are also many *unintended consequences* (Feller, 1997:56) residing within cooperative research, of which return on investment is one. The importance of continuing and building university engagement will also contribute to the protection of competitive, actionable knowledge within firms (Behrens & Gray, 2001:183).

The original research question in this dissertation is what drives South African industry firms to contract universities for R&D and how is this knowledge transferred between them. Together with this, another question is to what extent is there evidence of collaboration in knowledge generation, diffusion and/or application that will ultimately contribute to innovation? In other words, is there proof in South Africa that firms are getting a return-on-investment in R&D.

A HSRC report (2003:ix, 42, 50, 61, 63, 126, 127) confirms that:

- A total of 423 projects were incentivized through THRIP and the Innovation Fund;

- These projects involved 573 industry partners;
- The highest proportion of industry partners for THRIP was large enterprises (44%), followed by small enterprises (28%) and medium enterprises (25%). Only 3% are micro enterprises;
- A total of R869,1 million was spent by THRIP and the Innovation Fund on Higher Education Institutions, Science, Engineering and Technology Institutions/Industry linkages during 2002/3 and of this amount, 64% was THRIP expenditure and 36% was Innovation Fund expenditure;
- 1293 students were involved in the aforementioned 423 projects;
- A total of 885 publications were produced; and
- A further 35 patents and 296 artefacts were produced.

These figures suggest that the partnerships between universities and industry have resulted in tangible benefits with advantages being gained on both sides. These figures provide ample evidence of collaborations between universities and industry firms in South Africa.

5.1.4 The need to protect knowledge for competitive advantage

It is true that firms are inescapably bound up with the conditions of their environment and this goes hand-in-hand with location-related resources and advantages (Pfeffer & Salancik, 1978:1). Industry respondents to this survey have all indicated their acknowledgement that they need to protect their knowledge for competitive advantage. Within firms there are various knowledge assets which need protection. Literature has revealed that a firm's resources determine whether or not, and to what extent, they can engage in R&D collaborations with universities. The resources which determine the nature and level of collaborations, Powers (2000:33) has summarized as follows:

Resource Category	Description
Financial Resources	Monetary related resources such as capital investments from entrepreneurs, venture capitalists, equity holders, or banks as well as other types of financial capital such as retained earnings.
Physical Resources	A firm's plant and equipment, technology utilized, geographical location, and access to raw materials.
Human Capital Resources	Aspects of the firm's workforce including training, experience, judgement, intelligence, relationship, and insight.
Organizational Resources	The firm's organizational structure, planning, controlling, and coordinating systems, culture, and informal relationships between groups within and outside the firm.

Table 12: Firm Resource Categories (Powers, 2000:33)

Competitive advantage is inextricably linked to these assets and/or resources and should R&D done by universities provide indications of systems/procedures which can better utilize and protect these resources, industry will value the proposition. Industry partners engage universities in R&D if the following four fundamental objectives are met (Siegal et al., 1999:20-21). A R&D sponsoring company wants to be able:

- To validate the commercialization (in terms of business potential);
- To realistically assess the utility of the technology (i.e. its key applications, variations, modifications, etc. that would directly address known and specific problems and needs);
- To accurately target commercialization markets, industries or industrial sectors, which could potentially utilize the technology in a cost-effective manner; and

- To initiate commercial actions, which will help them determine technical and economic feasibility.

5.1.5 The need to close the knowledge gap

It is interesting to note that the need to close the knowledge gap and the need to protect knowledge for competitive advantage display a mean score which is close together, namely – 3.846 and 3.984 respectively. Industry partners obviously rate these drivers of knowledge transfer as moderately to very significant.

In the middle of Table 11 hovers the driver: the need to close the knowledge gap. The fact that the sample was judgemental and is too small to be representative of the 12 industry sectors that were measured in the survey, one cannot with certainty deduce what the reason might be for this moderate rating. Suffice to say that in South Africa closing the knowledge gap is becoming more and more critical in order to leapfrog this country into the information/knowledge era and in firms this implies continual education and training of the workforce to remain competitive. One possible method of closing the knowledge gap between universities and industry is by creating more opportunities for internships. This point carries the support of Etzkowitz who writes that internships, sponsored by companies and alumni organizations, are getting more and more popular (Etzkowitz et al., 2000:323).

5.1.6 International Trade

The role of international trade ranks on the lower end of the scale in terms of significance as indicated by industry respondents, but despite this, the mandate from the South African government is greater national and international collaborations between industry firms and universities. This calls for university-based entrepreneurship, which encompasses both commercialization and commodification as in patents and licenses (Jacob et al., 2003:1555).

The entrepreneurial university is a term, which is used to refer to universities which possess a wide range of new infrastructural

support mechanisms for fostering entrepreneurship within the organization as well as packaging entrepreneurship as a product of trade. An entrepreneurial university is one that views itself as a *bridgehead of innovation in modern societies* (Jacob et al., 2003:1556).

The increasing complexity of research and innovative activities militates in favour of using 'formal organizations (universities, R&D laboratories in firms, government laboratories, etc.) as opposed to individual innovators' as the most conducive environment to produce innovations (Dozi in Dozi et al., 1988:223).

The evidence of a growth in links between industry and universities suggests that firms tend to use universities to contribute to their R&D programs because this is a more 'flexible way to do research especially if that means having to fund and maintain own laboratories and infrastructure' (Godin & Gingras, 2000b:277). Firms of all sizes in all countries on most continents find it more expedient to collaborate with universities, because by doing so they are able to indirectly transfer part of their costs.

University research is stable and increasing and despite a real diversification of the loci of production, universities still are at *the heart of the knowledge system* and other industry actors as well as international trade stakeholders, rely heavily on their expertise. 'The presence of universities in the production of scientific research does not diminish in time, because universities have been able to stay at the centre of the knowledge production system by using collaboration mechanisms. By implication this points towards stronger interactions between components of the knowledge production system' (Godin & Gingras, 2000a:274, 277).

5.1.7 The need to protect Intellectual Property

The findings in this research project indicate that ownership of Intellectual Property rate third lowest of the nine drivers of knowledge transfer. This was surprising in view of the fact that Powell & Owen-

Smith (1998) considers the ownership of Intellectual Property Rights as a critical indicator of the extent to which projects are mutually collaborative and mutually beneficial. Table 11 indicates that intellectual property protection and ownership, together with the economic, financial and technology risks involved in knowledge transfer, feature prominently as serious concerns and real potential barriers in the eyes of industry partners who consider engaging universities in R&D. Understandably industry partners want the assurance that confidentiality will be paramount. This explains why industry organizations rate protective attitude as an extremely significant barrier to knowledge transfer.

In discussing the issue of Intellectual Property Rights, it remains important to mention the role of publication. Obviously high publication levels are an important consideration for maintaining and upholding scientific rigour, as well as promoting and generating new research outputs in related areas (HSRC, 2003:34) and this is especially critical for Higher Education Institutions, where the numbers of publication outputs are monitored as indicators of academic performance and institutional success. This HSRC report indicates that in South Africa, 91% of the completed and envisaged industry publications involve, or will involve, Higher Education Institution staff as authors (52% as single authors and 39% as co-authors with industry partners).

In the second instance universities are starting to implement pro-active 'portfolio management to generate revenue from their intellectual property' (Haase, 2004a:16-17). Universities having sole ownership of their Intellectual Property are a good idea, as long as it is managed for the benefit of the institutions; for example Stellenbosch University's spin-off company called UNISTELL GROUP HOLDINGS, which commercializes innovations developed at the university (Bull in Haase, 2004b:17). Henderson et al. (1998) found that high patenting universities generate higher quality inventions, which are more likely to be licensed.

Shane (2002:136) has shown that university inventions are more likely to be licensed when patents are effective and that the effectiveness of patents increases royalties earned for inventions licensed to non-inventors.

Firms have rated protecting their intellectual property high in terms of significance and the rating in Table 11 bears out what has been revealed in literature. To reiterate, when are patents less effective? Firms indicate that 'patents are less effective when they are unlikely to be held valid if challenged, if firms cannot enforce them, if competition can legally *invent around* patents, if the technology is moving so fast that patents are irrelevant, if patent documents require disclosure of too much proprietary information, if licensing is required by court decisions, or if firms participate in cross-licensing agreements with competitors' (Levin et al. in Shane, 2002:125).

Based on the above, it is therefore interesting to note that 'in South Africa 50% of the Higher Education Institutions and industry partners share the Intellectual Property Rights, while 30% of the projects allocate the Intellectual Property Rights to industry alone and 4% to the Higher Education Institution alone. No mention is made of what the situation is with the other 16%. THRIP does not prescribe how Intellectual Property Rights are distributed, but THRIP does require that the parties agree upon the distribution of these rights before commencement of any project. The Innovation Fund, however, requires that intellectual property be vested with the consortium of partners and reserves the right to claim ownership of intellectual property if, after five years, the funder is able to determine that no attempt has been made to exploit the results of the project' (HSRC, 2003:32, 33).

5.1.8 Geographic Proximity between knowledge source and recipient

Even though industry respondents in South Africa have indicated that geographic proximity does not rate high at all in terms of significance as a driver of knowledge transfer, it must be said that universities

need to heed Mathiassen's plea (2002:321) for more relevance without abandoning R&D research rigour. Academics must find ways to increase the relevance of their research to industry by reconsidering topic selection, as well as the purpose, content and readability of the articles they write.

One key strategy in higher education thus is the notion of *responsiveness*, which refers to a shift of higher education to a more open and interactive system, responding to the social, cultural, political and economic needs of its environment and adapting itself to the changes in this environment. Greater responsiveness implies that higher education should take seriously the problems and challenges presented by the societal context in which it operates (HSRC, 2003:1).

This being the case it makes sound financial sense for industries to make use of universities and to diminish geographic proximity problems between them.

5.1.9 War, terrorism and natural disasters

Moving on to the driver of war, terrorism and natural disasters, which has a mean rating of 2.873, we see that this driver finds itself on the lowest order of significance. This indicates that, according to the respondents, it is the least significant of the nine drivers in their opinion and of minimal importance in their collaborations with universities.

Gerner & Schrodt (2002:221-224) have illustrated how policy makers, academics, and activists alike often invoke the word *terrorism* inconsistently. In times of crisis, when the totally unexpected becomes reality, society expects knowledge workers to serve their communities with knowledge, explanation, insights and policy alternatives. In the contemporary global news environment the critical issue was the old difficulty of *finding out*. It has been replaced by the new challenge of *filtering out* say these authors. The filtering

issues, which can prove valuable both to universities and their collaborating industry firms, are the following:

- The short-term task is one of detecting rumours and filling in missing details. One's theoretical knowledge and overall understanding of a situation best deal with this.
- The intermediate problem involves sorting out conflicting interpretation of events and anticipating future political decisions. This is accomplished by investigating and then *triangulating* multiple sources of information, largely using the Web and email.
- The long-term challenge is counteracting inaccurate public perceptions. This is addressed through general educational efforts (Gerner & Schrodt, 2002:221-224).

In closing the comments on this driver of knowledge transfer, it can be said that whether we like it or not, the elite print media are the filter through which academic ideas get into the policy community (Gerner & Schrodt, 2002:228) and that is why these authors do not subscribe to the myth of a *value free* social science, because this is often advanced by people who are simply comfortable with the value-laden *status quo*, which they find unacceptable.

5.2 Research Limitations

As previously mentioned, the RESEARCH MARKETING & TECHNOLOGY COMMERCIALIZATION SURVEY was originally targeted at 180 firms. This figure was increased to 211, but only 69 industry firms in South Africa responded by the cut-off date of 31 March 2006. The paucity of the sample size has, however, allowed some reasonable, but cautious conclusions to be drawn on the nine drivers of knowledge transfer incorporated in this survey. These drivers of knowledge transfer raise several issues of relevance in addressing the barriers of knowledge transfer that exist in South Africa.

The limitations of this research project were firstly the fact that so few South African firms responded to the request to participate. Secondly there were some of the possible twelve industry sectors in which there was very poor representation. The research results are also limited in terms of generalizability, firstly due to the non-probablistic population sampled and secondly due to the plethora of business and industry types not included in the sample frame.

5.3 Concluding Remarks

This research dissertation has focussed on the drivers of knowledge transfer between industry firms and universities in South Africa. Knowledge transfer appears to work best when it is seen not so much as a relay race, but as a team sport. Knowledge transfer is not a process in which – during the first few rounds of the race – the knowledge-baton is kept inside the university, while it is passed on to the outside world only during the last rounds. Rather, it is 'a game during which the ball moves continually between the players and in which all players have to collaborate and share resources to win' (Entrepreneurial Higher Education Institution, 2002:10-11).

Friedman (1999:xiii-xiv) is hopeful that individuals and countries will be able to 'turn their aspirations into achievements for technology, properly harnessed and liberally distributed, has the power to erase not just geographical borders, but also human ones.' Furthermore, with today's markets being so diverse and becoming more and more unpredictable, firms cannot be made immune from crisis. Globalization demands that our society needs to move faster, work smarter and take more risks than at any time in our history. We have no option but to partake in this wrenching process.

Based on the framework provided by the Knowledge Management *Pyramid of Excellence* (Hiscock, 2003:25) the aspects mentioned below can be seen as practical best practices which can be incorporated into firms to better the diffusion of knowledge between them. The six levels (from lowest to highest) in this Pyramid of Excellence are:

- Strategic positioning and a clear knowledge management business case;
- Establishment of a reliable base of best practices;
- Improved knowledge transfer on all levels;
- Improved learning and competency on all levels;
- Increased innovation levels;
- Intellectual asset management which adds business value; and
- Becoming an admired knowledge enterprise.

It is vital to remember that for both firms and universities 'it is *learning* and not knowledge that is the primary source of value. As the shelf life of an item of knowledge approaches zero, knowledge ceases to be power; the ability to change knowledge – to learn – becomes the source of power' (Jacques in Prichard et al., 2000:208). Firms have to not only retain but *foster* worker-embodied knowledge (Wilmott, 2000:218).

If knowledge management is a collection of processes that govern the creation, dissemination, and utilization of knowledge in an organization (Newman, 1991), then firms have to provide an enabling environment for the development, nurturing, utilization and sharing of employees tacit knowledge (Ajiferuke, 2003:1). In considering the drivers of knowledge transfer addressed in this dissertation, we must be reminded that in the widest sense, 'knowledge includes components of science and rationality as well as craftsmanship and other skills' (Alvesson, 1993:997, 998) and this motivates for an extra dose of scepticism when accounting for it.

Yet universities, as providers of scientific R&D knowledge, realise that one role of science and knowledge is to solve problems vital to society while working for the common good in the most effective way

(Brante, 1988:122). It is believed that the development, ownership, protection and utilization of all South African knowledge assets is necessary in order to compete in the new global economy.

Only firms which are able to protect, re-deploy, build, buy, combine or recombine their knowledge assets and then deploy them according to rapidly changing circumstances and client needs, stand to survive. Competition in the Triple Helix arena means that all three parties should sharpen their entrepreneurial skills to effectuate transformation of the South African science and technology landscape.

South Africa is a society faced with huge, lingering effects of apartheid, but the changing world of work calls for adaptability. This spells out a need to 'foster intellectual curiosity about alternatives together with robust intellectual debate' (O'Connell, 2006:8) between stakeholders in industry and their collaborating universities. Higher education is thus tasked with the arduous formation of a critical, creative and compassionate citizenry. Nothing else will suffice.

'What is hidden and unbeknown and cannot be discovered by scientific research will most likely be discovered by accident, if at all, by the one who is most observing' (Schwartz, 2004:63-64). If firms and universities are observant and are able to leverage R&D and convert more meaningful arbitrary occurrences into opportunities, they may change an economy and the world. The number of problems facing the world is mushrooming at the same time that massive amounts of new knowledge are being created that could serve the process of invention. Firms and universities need to apply thinking strategies to their surroundings, to increase collaborations and knowledge transfer while ensuring that sufficient mutual benefits can be derived. This can provide the 'much-needed oxygen into the rarefied world of academia' and inventors may find that they actually can 'convert mud and weeds into an economy' (Schwartz, 2004:203).

5.4 Areas for future research

There are several areas in which research efforts can be focussed in future.

- Further research is needed to understanding the mechanisms by which universities transfer R&D knowledge.

- If, according to the WORLD SUMMIT ON SUSTAINABLE DEVELOPMENT (cited by Yeld, 2006:11), sustainable development rest on the three pillars of (a) economic development; (b) social development; and (c) environmental protection, then South African firms and universities are mandated to develop the scientific labour force (DST, 2005:4). This implies greater levels of collaborations between all sectors of business and industry as well Higher Education Institutions. There is a distinct need to explore creative ways of combining and pooling capacity nationally and within the continent and there is also a need to create distinct areas of research strength (DST, 2005:5). Only by deepening research knowledge and sustainable research strengths will South Africa be able to differentiate itself. In order to create new understanding one will need, what Martin (1995:155) refers to as *large pools of experts*, which are often located in universities and laboratories who can be contracted to undertake R&D projects for their industry partners. In this way knowledge transfer between these parties can be increased and bettered.

- Future research deemed necessary also includes studies, which will explore collaborative endeavours which increase competitiveness, efficiency and social development in the context of the pressures of globalization and the global economy. In this respect Castells (HSRC, 2003:2) refers to 'increased networking between organizations within the seemingly paradoxical paradigm of competition and collaboration'. Organizations within different sectors are

beginning to see the benefits of working collaboratively, rather than in isolation in order that the efficiency, quality and quantity of outputs may be increased.

The findings of this research project have brought other important directions for future research to light, namely:

- Research that will test the relationships between industry firms and universities which involve the use of organizational intelligence (e.g. competitive intelligence, sales and marketing intelligence, engineering information, management consultants' reports, and legal briefs);
- Research into the differences in relationship processes between universities and industry and how these collaborations affect information utilization;
- Future research should also examine similarities and differences in knowledge transfer between industry firms and various departments within South African universities;
- Research is also required into the what the role of economic factors, social norms and power have on university/industry relationships;
- Future research can also examine the role of trust in South African firms and the universities with whom they collaborate, in terms of the productivity and longevity of these relationships; for if trust does not ultimately flow in two directions, it is likely to disappear (Moorman, Zaltman & Deshpande, 1992:325);
- Lastly further in-depth research is required into the barriers to knowledge transfer as well as the success factors and challenges facing South African industries in these collaborative relationships.

It is hoped that this research dissertation has contributed in a small way to a major research thrust that is emerging in South Africa and that the results of this research will expand our understanding of deliberate knowledge transfer activities between industry partners and universities. The future alone, however, will tell whether academics will have 'the ability to adapt to, to articulate, and to pursue new directions in basic and applied research and training' (Grossman et al., 2001:150), and whether the rate of investment in long-term academic research is adequate to meet emerging challenges and opportunities.

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