PROMOTING HIGHER EDUCATION - INDUSTRY

PARTNERSHIPS AND COLLABORATIONS

A REPORT TO THE RESEARCH AND INNOVATION STRATEGY GROUP
HIGHER EDUCATION SOUTH AFRICA

HESA
HIGHER EDUCATION
SOUTH AFRICA

THE VOICE OF HIGHER EDUCATION LEADERSHIP

ACRONYMS

BEE	Black Economic Empowerment
CHE	Council on Higher Education
CHEC	Cape Higher Education Consortium
DHET	Department of Higher Education and Training
DST	Department of Science and Technology
DTI	Department of Trade and Industry
ECSECC	Eastern Cape Socio Economic Consultative Council
FET	Further Education and Training
HEI	Higher Education Institution
HEQC	Higher Education Quality Committee
HESA	Higher Education South Africa
HSRC	Human Sciences Research Council
ICT	Information and Communication Technology
IP Act	Intellectual Property Rights Act
IPR	Intellectual Property Rights
MNE	Multi-national Enterprises
NACI	National Advisory Council on Innovation
NIPMO	National Intellectual Property Management Office
NRF	National Research Foundation
NSFAS	National Student Financial Aid Scheme
NSI	National Science and Innovation
OECD	Organisation for Economic Cooperation and Development
R&D	Research and Development
RISG	Research and Innovation Strategy Group
SADC	Southern African Development Community
SAICA	South African Institute for Chartered Accountants
SAHECEF	South African Higher Education Community Engagement Forum
SARIMA	South African Research and Innovation Management Association
SET	Science, Engineering and Technology
SETI	Science, Engineering and Technology Institutions
SMME	Small, Medium and Micro Enterprises
SPII	Support Programme for Industrial Innovation
TB	Tuberculosis
THRIP	Technology for Human Resources and Innovation Programme
TIA	Technology and Innovation Agency
TIPTOP	Technology Innovation Promotion through the Transfer of People
TTO	Technology Transfer Offices
UK	United Kingdom
US	United States of America

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EXECUTIVE **SUMMARY**

The global demand for greater social accountability, responsiveness and relevance on the part of higher education has manifest in an emphasis on universities' contribution to the national economy. As knowledge becomes a force determining productivity and competitiveness, the rapid spread of 'open innovation' and collaboration between firms in emerging and advanced economies around the globe has placed special attention on universities and their potential to enhance firms' technological capabilities.

There is increasing attention paid to the potential contribution of universities as knowledge producers interacting with firms to build learning and technological capabilities in a national system of innovation, and hence, contributing to sustained economic growth and structural change, in the specific conditions of developing countries (Liefner and Schiller 2008, Mazzoleni 2008, Schiller and Brimble 2009).

Knowledge-based institutions play a key role in preparing graduates with appropriate scarce and critical skills, and in contributing research to the development of new technology, new organizational forms and innovation. University education produces individuals with fundamental competencies able to absorb new technologies for firms, thus building and increasing capabilities for firms and industries in a national economy. University research can provide missing or complementary basic, applied or experimental research to inform firms' innovation and R&D activities. In turn, industry has been identified as a key partner for higher education, as a potential source of much needed 'third stream' income.

These trends are evident in South Africa, with attempts to promote university-industry linkages from the late 1990s, as part of new policy frameworks to bridge the 'innovation chasm' between the science and technology system and the industrial system, and thus contribute to build a strong national system of innovation (DACST 1996, DST 2002).

Recent national policy shifts mean that higher education institutions are now required to align and coordinate their strategies with the state's reprioritization of socio-economic development goals that favour the poor and socially marginalized (HESA 2009). Knowledge and innovation are critical to socio-economic growth and development, but in a country of limited resources like South Africa, interaction and partnerships between universities, science councils, and the private sector are even more essential to achieve these goals.

The emphasis is shifting from promoting university interaction with firms in the private sector in high technology fields, to include interaction with a broader range of social partners - productive agents in the informal and rural sectors, and public sector partners such as communities and civil society organizations (Kruss 2010, Goddard 2010).

The Research and Innovation Strategy Group of Higher Education South Africa (HESA) commissioned this research report, to inform advocacy to promote university-industry interaction in key sectors in South Africa, with university, government and business partners.

In relation to university-industry interaction, HESA's concern was to:

1. Understand current forms of collaboration and partnership between university and industry, and the benefits and constraints of these forms for research and innovation.
2. Understand the dynamics of best-practice collaboration in key sectors in relation to international trends.
3. Understand the institutional dynamics within universities and the policy interventions in the national system of innovation that support and facilitate university-industry interaction.

The purpose was to lay the foundation for a common framework and a functional model for HESA and its members to anchor, promote and sustain university-industry partnerships.

The report presents an analysis of current trends and best practice, and of policies and structural arrangements, in order to recommend a framework appropriate to the South African context, to guide HESA members' promotion of university-industry interaction.

SECTION ONE

AN OVERVIEW OF THE SCALE AND FORMS OF INTERACTION BETWEEN UNIVERSITY AND INDUSTRY

Section One constructs an overview of 'what exists' in the practices of university and industry in the South African context. It sets out a conceptual model of diverse forms of interaction and uses it to analyse the scale and forms of academics' activities, as well as the interactions incentivized by public funding schemes and then, to analyse the activities of innovating firms and R&D performing firms.

Evidence from a 2010 survey of academics at five universities representing diverse institutional types is that academics generally view interaction with external social partners as desirable or an accepted aspect of their work. Sectoral, institutional and knowledge field differences are highlighted in the analysis, to show that there is a wide possible range of activities, forms and frequencies of interaction across the system.

The strongest aggregative trends that emerge from the analysis of the practices of academics at these five universities are:

1. Academics are interpreting the imperative to engage with external social partners very broadly, and these interpretations are closely linked to their core academic work of teaching and research.
2. Approximately half of all academics indicated that they interact with firm partners, the majority with SMMEs and large local firms, and an important emergent trend is interaction with MNEs.
3. Academics in all knowledge fields, not only SET are interacting with firms, and there are a similar number of linkages reported by academics in Business and Commerce, and the Humanities fields.
4. The type of relationship tended to take traditional forms related to teaching, and may involve sponsorship and funding from firms to the university.
5. Research related newly dominant forms are consultancy, expert advice and contracts, while there are emergent network forms of interaction and fewer entrepreneurial forms evident.
6. The channels of interaction are generally informal, indirect and not knowledge intensive.
7. The outputs tend to be traditionally academic related and typically 'walking on legs'.
8. The outcomes and benefits tend to favour academics rather than firms, although social development related outcomes are also prevalent.

It is useful for institutional management and leadership to understand these general trends, and to analyse further the patterns of academic practices in distinct types of university or knowledge fields, as a basis for developing policy, strategy and mechanisms to build interactive capabilities.

However, understanding what academics currently do provides only one perspective on how interaction can be promoted, that needs to be complemented by the perspective of firms, and what they demand from universities. Investigating which firms seek to cooperate with universities and why, can inform a more comprehensive understanding of the ways in which universities can meet the needs of firms.

In the late 1990s, government established funding schemes that aimed to incentivize technological advancement and innovation through the promotion of collaboration between firms, universities and science councils to ensure multi-institutional and multi-sectoral cross-transference of technological knowledge. The Technology for Human Resources and Innovation Programme (THRIP) and Innovation Fund schemes aimed to advance research, human resource capacity and technology outputs in science, technology and engineering fields, in order to improve the competitiveness of South African industry. The projects funded under these schemes typically entail service or network forms of interaction, involving firms, universities and often, SETIs or other firms as partners on R&D and technology development.

The THRIP grant scheme in particular has been extremely successful in promoting university-firm interaction (HSRC 2003, Letseka 2005). Two trends stand out that suggest the impact of THRIP for promoting university interaction across the higher education system is increasingly limited. First, funding still tends to be concentrated at large historically advantaged research universities with strong SET capacity. Second, the total available for THRIP funding has declined from 2000 to 2009 (HSRC 2003, THRIP 2009). Thus, firms are motivated to interact with firms on their R&D and innovation activities when there is significant government funding as an incentive, but they typically prefer to interact with a few universities that have a reputation for research productivity and quality.

To obtain a view of the practices of firms in general, evidence from national innovation and R&D surveys was analysed. Interaction is more commonly initiated when industry comes forward with a problem, and universities are used for their expertise to solve that problem. Less commonly, academia will present an opportunity, and propose collaboration to industry. Understanding firm demand is thus critical.

In general, there is not a high demand for knowledge from, or direct cooperation with, universities on the part of most innovating firms in South Africa, but there is a stronger demand from the smaller set of R&D performing firms. If we aggregate, the strongest trend evident is that those firms that interact with universities, are more likely to be to be large firms in the manufacturing sector, research intensive, seeking complementary capacity. More firms tend to cooperate with universities on their R&D activities, also primarily in the manufacturing sector, and there is a group of small firms that seek to substitute for missing experimental R&D capacity from universities.

The R&D and innovation survey datasets can be mined further to disaggregate rather than analyse commonalities, in order to identify the propensity of different types of firms in specific sectors, with different R&D intensities and with different levels of technology, to collaborate with universities and other partners in relation to specific types of research. The analysis highlights the distinct patterns of interaction of firms in different sectors, and hence, the significance of understanding sectoral dynamics. These datasets provide an important source of information for universities to understand firm demand and how to focus their efforts to maximum effect.

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SECTION TWO

COORDINATION AND ALIGNMENT ACROSS THE NATIONAL SYSTEM OF INNOVATION

Section Two shifts to consider 'what exists' at the macro-level, in the policy domain and the national system of innovation, that serves to facilitate or constrain interaction. It illustrates the absence – and significance - of complementarities and linkages between government agencies, universities and firms, identifies key intermediary agencies and emphasizes recent policy shifts that may impact in the immediate future.

Case studies highlight the need for more effective coordination and alignment between the organizations and actors within the national system of innovation, if interaction is to have successful outcomes for universities, firms, technological upgrading and competitiveness. It is evident that a critical problem lies not necessarily in the policy frameworks to promote science and technology, but in the alignment and coordination between sub-systems of the national system of innovation, and within subsystems, between key agencies and actors.

Recent shifts and development in the national policy framework for higher education, science and technology and economic development are likely to have important implications for the promotion of university-firm interaction.

HESA's promotion of university-firm interaction needs to be based on a thorough understanding of these policy conditions, and how they can facilitate or constrain specific forms of interaction. DTI, DST and NRF mechanisms tend to promote service forms (contracts) or network forms of interaction, but significantly, the new TIA mechanisms and the structures established by the IP Act tend to promote primarily entrepreneurial forms of interaction. The CHE DHET, NACI and NRF as key intermediary agencies, are likely to promote traditional forms of interaction. Regional and local partners can promote all forms of interaction, and are particularly well placed for network forms of interaction that require proximity and the exchange of tacit knowledge.

HESA will need to build coordinating relationships with all of these agencies, in order to promote the full spectrum of forms of interaction.

SECTION THREE

BALANCING FORMS OF INTERACTION AT THE INSTITUTIONAL LEVEL

Most often, national policy frameworks provide normative expectations of how a higher education system should develop, but few operational arguments as to how to achieve these multiple goals, nor an understanding of the limitations of universities and of the challenges posed to their present structures. Universities are under pressure to transform internally to meet the external challenges of social accountability and to contribute to socio-economic development.

Section Three moves to focus on the meso- and micro-levels, on the promotion of interaction within diverse institutions, the level that is within the power of leaders, managers and academics to shape and influence interaction more directly.

It addresses the disjuncture between a focus on university-industry interaction and community engagement, and how institutions can develop a more integrated and comprehensive approach.

The South Africa higher education policy framework has encouraged universities to define a differentiated mission based on their institutional type, their historical strengths and their strategic niche areas.

At the institutional level, it is significant for institutions to develop a balance of forms of interaction with industry and other external social partners that is appropriate to their strategic direction and capabilities (Kruss 2005a, 2006b). To do so, institutions need an analytical framework to be able to identify what the appropriate balance can be in specific knowledge fields, and across the institution as a whole. They also need to know what are the policies, structures and mechanisms they can use to promote interaction with firms.

The matrix of forms of interaction is proposed to identify the distinct pattern within an institution, and to consider who benefits from the different forms of interaction and how. Which channels of university-firm interaction are more likely to benefit and less likely to risk learning and capability building in individual universities, and in the national system of innovation? The importance of balancing forms of interaction with different benefits and risks in terms of institutional strategy and strengths, and of understanding institutional approaches – the policies, structures and mechanisms put in place to promote interaction – is proposed.

A university may have an excellent academic reputation and research or teaching capacity, but there is no one-to-one relationship between this capacity and successful interaction. Leveraging competencies into interactive capabilities depends on abilities and circumstances (von Tunzelmann 2007). A research unit in a university may have competencies in the form of academics with PhDs that represent a potential critical mass of research expertise that could be a basis for interaction. However, they may find themselves in imposed circumstances that do not allow them to benefit from this expertise. Some of these circumstances may be external to the university, in relation to firm demand or the policy environment.

Of particular concern are the imposed circumstances that are internal to the university – and subject to institutional change efforts. It may be for instance, that prevailing academic incentive systems do not value and reward applied research conducted for firms, or it may be that significant academic groupings resist new strategies promoted by university leaderships, or it may be that academics lack understanding of external needs and mechanisms of effective interaction with firms, or the way in which the university is organized internally may militate against effective interaction with firms.

Drawing on a study by Martin (2000) of the institutional practices typically established to manage university-industry relations in twelve developing countries, a distinction was drawn between internal and external interface structures to build interactive capabilities. Internal interface structures refers to dedicated forms of organizational development, such as specialized internal structures for technology transfer, dedicated managerial posts, offices for continuing education or technology innovation centres.

External interface structures play a similar role but they typically have a separate legal status from the institution, to enhance flexibility and responsiveness, and to create a professional, higher-status, market-related interface, such as university-owned companies, incubators, science parks and consultancy centres.

The promotion of different forms of interaction requires different interface structures and mechanisms. Commercial forms require incubators and IPR offices, but services forms such as consultancy require internal policies to regulate time and academic workloads, while skills development requires mechanisms for consultation between academics and sectoral organizations. Internal and external interface mechanisms will need to be aligned with the pattern of forms of interaction promoted at each institution.

Over the past three or four years, a shift towards institutionalization of a broader concept of community engagement or social responsiveness as integral to academic scholarship is emerging (CHE 2010, University of Witwatersrand 2009, Muller 2010). The HEQC institutional audit process was a direct driver of more systematic integration of 'community engagement' within institutional missions, structures and incentive schemes, in relation to teaching, research and outreach or service. This provides an opportunity for universities to reconceptualise interaction in terms of socio-economic development goals in an integrated manner.

Typically, there are separate structures and mechanisms within a university to promote research, innovation and 'community engagement'. The challenge – as at the national level – is to bridge a potential disjuncture that sees these structures operating on their own separate tracks, and to promote internal coordination and alignment.

At some institutions, a new concept of social responsiveness or engagement is being articulated, so that a wide range of partners of interaction - including firms, communities and government – and a wide range of forms of interaction - in relation to teaching, research and outreach - are recognized. Local government and farmers are critical external partners of universities located in rural areas, for example, rather than firms.

The conditions are favourable for a cross-fertilisation of ideas from those within universities who have gained valuable experience of what is required to interact with firms in a beneficial way, and those who have experience in addressing a range of national socio-economic priorities, whether health, poverty or the environment. How may technology transfer offices adapt their expertise to include local government or community partners, or intellectual property and commercialization experts extend their reach to create not-for-profit community-based spin-off companies? Precedents exist for what is possible, where academics are involved in multi-disciplinary teams to address complex social problems through research and innovation, in ways that inform teaching and learning and the academic project.

Examples are new software generated to adapt cell-phones for health interventions in impoverished communities, or genetic research on plants or seeds in networks with small growers, local communities and large firms.

Such reconceptualisation is important as a basis for stronger internal alignment and coordination within institutions.

SECTION FOUR
TOWARDS A STRATEGY FOR HESA

The research revealed complexity, and the multi-layered nature of the task. A simple, uniform framework and model applicable to all HESA members is not possible. What is possible is to develop a framework and a set of analytical tools to promote university-firm interaction in a more integrated, contextually appropriate, differentiated and specific manner than has been the case to date.

The core of such a framework rests on the assumption that what is required is to build interactive capabilities. An institution may have strong academic capacity but find itself in imposed circumstances that constrain interaction with firms. Imposed circumstances may be external to the university in relation to firm demand or the policy environment, or internal to the university in relation to institutional policies, structures and interface mechanisms. Of course, in the South African context, some institutions may lack academic capacity and be required to build it at the same time as developing interactive capabilities.

HESA can intervene in relation to external circumstances, but their efforts should be focused primarily on the imposed circumstances that are internal to the university and hence, subject to its members' own institutional change efforts.

Key principles for a framework drawn from the analysis are:

1. The conceptualization of university-firm interaction within a broader framework of university responsiveness and interaction, that includes teaching, research and outreach activities, and that includes a range of external social partners.
2. An appreciation and promotion of differentiated university approaches shaped by institutional types, knowledge niches and expertise, institutional historical trajectories and cultures.
3. The promotion of a strategic balance of diverse forms of interaction with their attendant benefits and risks, that address university and firm priorities and contribute to build the national system of innovation.
4. The development of interactive capabilities on the part of academics, heads of departments, institutional managers and leaders.
5. An understanding of firm demand and the specificities of innovation and R&D dynamics in priority sectors and relevant knowledge fields.
6. The promotion of coordination and alignment between universities and other agencies in the national system of innovation, and of alignment with national socio-economic development priorities.
7. The promotion of stronger collaboration within the national science and technology system across institutional boundaries of universities and science councils, as a basis for more sustainable interaction.

Based on the these principles, possible roles are identified for HESA as a national coordinating and advocacy agency working at three levels, in relation to internal and to external imposed circumstances:

1. HESA's role in relation to its member institutions should focus on building institutional interactive capabilities.
2. HESA's role in relation to firm demand should focus on promoting sectoral interactive capabilities.
3. HESA's role at the policy level should focus on promoting coordination and alignment with government and other agencies in the NSI

INTRODUCTION

The global demand for greater social accountability, responsiveness and relevance on the part of higher education has manifest in an emphasis on universities' contribution to the national economy. As knowledge becomes a force determining productivity and competitiveness, the rapid spread of 'open innovation' and collaboration between firms in emerging and advanced economies around the globe has placed special attention on universities and their potential to enhance firms' technological capabilities.

AIM OF THE PROJECT

There is increasing attention paid to the potential contribution of universities as knowledge producers interacting with firms to build learning and technological capabilities in a national system of innovation, and hence, contributing to sustained economic growth and structural change, in the specific conditions of developing countries (Liefner and Schiller 2008, Mazzoleni 2008, Schiller and Brimble 2009).

Knowledge-based institutions play a key role in preparing graduates with appropriate scarce and critical skills, and in contributing research to the development of new technology, new organizational forms and innovation. University education produces individuals with fundamental competencies able to absorb new technologies for firms, thus building and increasing capabilities for firms and industries in a national economy. University research can provide missing or complementary basic, applied or experimental research to inform firms' innovation and R&D activities. In turn, industry has been identified as a key partner for higher education, as a potential source of much-needed 'third stream' income.

These trends are evident in South Africa, with attempts to promote university-industry linkages from the late 1990s, as part of new policy frameworks to bridge the 'innovation chasm' between the science and technology system and the industrial system, and thus contribute to build a strong national system of innovation (DACST 1996, DST 2002).

Recent national policy shifts mean that higher education institutions are now required to align and coordinate their strategies with the state's reprioritization of socio-economic development goals that favour the poor and socially marginalized (HESA 2009). Knowledge and innovation are critical to socio-economic growth and development, but in a country of limited resources like South Africa, interaction and partnerships between universities, science councils, and the private sector are even more essential to achieve these goals.

The emphasis is shifting from promoting university interaction with firms in the private sector in high technology fields, to include interaction with a broader range of social partners - productive agents in the informal and rural sectors, and public sector partners such as communities and civil society organizations (Kruss 2010, Goddard 2010).

In this light, the Research and Innovation Strategy Group of Higher Education South Africa (HESA) commissioned research to inform advocacy to promote university-industry interaction in key sectors in South Africa, with university, government and business partners.

HESA's strategic goal is to work with its member institutions to promote pathways to a diverse and effective higher education system in South Africa (HESA 2009). The system faces a strong demand for access on the part of underprepared and underfunded students, but it is constrained by a declining funding base in the context of global economic recession, and moreover, it is still dealing with the unintended consequences of complex national policy changes and restructuring. These structural dynamics form the context for all of HESA's strategic interventions.

In relation to university-industry interaction, HESA's concern was to:

1. Understand current forms of collaboration and partnership between university and industry, and the benefits and constraints of these forms for research and innovation
2. Understand the dynamics of best-practice collaboration in key sectors in relation to international trends
3. Understand the institutional dynamics within universities and the policy interventions in the national system of innovation that support and facilitate university-industry interaction

The purpose was to lay the foundation for a common framework and a functional model for HESA and its members to anchor, promote and sustain university-industry partnerships.

This report will present an analysis of current trends and best practice, and of policies and structural arrangements, in order to recommend a framework appropriate to the South African context, to guide HESA members' promotion of university-industry interaction.

METHODOLOGY

The primary methodology is a synthesis drawing on empirical research conducted by the Human Sciences Research Council (HSRC) over the past eight years, complemented by fresh analysis of available data sources, and key informant interviews.

A synthesis of existing research

HSRC has developed a strong research foundation to analyse university-firm interaction since 2003, in relation to national development in South Africa. The research explores the institutional policy, structures and mechanisms to promote industry partnership (HSRC 2003, Klerck 2005, Lorentzen et al 2005, Kruss 2005a, 2005b, 2008a) and considers what facilitates best practice knowledge networks in key priority sectors, particularly ICT, new materials and biotechnology (Kruss 2006a, 2006b, 2007).

The research was extended comparatively, in sub-Saharan Africa (Kruss 2008c, 2009, Kruss et al 2009), and in the SADC region specifically (Kruss and Petersen 2009) to problematise the forms of interaction appropriate in African contexts. In addition, it was extended to comparative work with developed and transition countries in Europe on public science-industry linkages and with developed and transition countries in Brazil and India, on the role of universities in the evolution of global innovation networks. Case studies of knowledge networks in the health biotechnology sector (Kruss 2008b) highlight the effect of alignment or misalignment in the national system of innovation and between the priorities and capabilities of universities and firms, in promoting networks. Case studies of global innovation networks in the agro-food processing sector highlight the ways in which South African universities are drawn into the emerging phenomenon of global innovation networks, collaborating with partners in multi-national companies, local firms and foreign universities or research institutes, in the agro-food processing sector (Albuquerque et al 2011).

This body of work informed the conceptual framework for the analysis of empirical data, as well as served as sources of case study material and analytical insights in Sections Two and Three.

Constructing an overview from the available datasets

Unfortunately, there is no comprehensive national census or database of interaction across the 23 higher education institutions, as there is in a country like Brazil, for example (Rapini et al 2009). Hence, it is necessary to construct an overview of key trends from the available data. A number of sources that provide complementary datasets were mined in order to create a more holistic overview, as a next best option.

First, a customized analysis of newly available data from a research project undertaken by the HSRC in 2010 was undertaken. The database was developed from a survey of academics at five universities, to determine the scale and forms of interaction with a wide range of external social partners – whether firms, communities, local government or development agencies. A sample of 2 159 academics was drawn from five institutions representing the main higher education types in South Africa: a rural university, a university of technology, two research universities and a comprehensive university. This dataset provides an indication of the scale and forms of interaction with firms as opposed to other social partners, amongst the main types of higher education institutions. A single academic may have multiple relationships or outputs with a range of partners, so the figures presented in the tables in Section One below represent the number of linkages with industry partners, and not the number of academics involved, unless specified otherwise.

Second, an analysis of National Innovation Survey (2005) and R&D Survey (2005-2008) datasets, focused on items related to collaboration between university and industry, provides an indication of the scale of interaction nationally amongst all firms, amongst innovating firms and amongst R&D performing firms.

Third, tables were extracted from THRIP reports, to gain an understanding of the scale and outputs of linkages, in a subset of firms and universities incentivized to collaborate by government funding.

Taken together, analysis of these datasets in Section One allows for the construction of a 'best possible' overview of the scale and forms of university-firm interaction.

Key informant overviews

In order to develop a functional model to promote university-industry partnerships, it will be important to understand the policies, structures and incentive mechanisms that individual universities currently employ, as well as the policy instruments adopted by intermediary organisations in the national system of innovation to promote partnerships.

There have been two recent developments in the national system of innovation that potentially impact on the context for promoting university-industry interaction. The first is the establishment of the Technology and Innovation Agency (TIA) as a national champion to bridge the research and innovation spectrum and coordinate what threatened to become fragmented efforts of a number of innovation centres and platforms, incubators and funding schemes. The second is a new Intellectual Property Rights Act that draws inspiration from the Bah Doyle Act in the US, to ensure commercial benefits from publicly funded science in the national interest.

Key informant interviews were held with representatives from TIA and other relevant organizations such as the National Research Foundation, the Council on Higher Education, the National Advisory Committee on Innovation and the Support Programme for Industrial Innovation. Together with documentary sources accessed via the internet on way in which these organizations promote or incentivize university-industry interaction, the interviews informed the analysis in Section Two.

THE REPORT

The foundation for developing a strategic framework is to have a solid understanding of 'what exists', from which HESA can proceed to engage with member institutions. This is the task of the first three sections of the report: to provide research evidence to inform the framework and approaches presented in the final section.

Section One constructs an overview of 'what exists' in the practices of university and industry in the South African context.

It sets out a conceptual model of forms of interaction and uses it to analyse the scale and forms of academics' activities, as well as the interactions incentivized by public funding schemes and then, to analyse the activities of innovating firms and R&D performing firms. Sectoral, institutional and knowledge field differences are highlighted.

Section Two considers 'what exists' at the macro-level, in the policy domain and the national system of innovation that facilitates and constrains interaction. It illustrates the absence – and significance - of complementarities and linkages between government agencies, universities and firms, identifies key intermediary agencies and emphasizes recent policy shifts that may impact in the immediate future.

Section Three moves to the meso- and micro-levels to consider what exists within diverse universities to promote and manage interaction. It proposes the importance of balancing forms of interaction with different benefits and risks in terms of institutional strategy and strengths, and of understanding institutional approaches – the policies, structures and mechanisms put in place to promote interaction. It addresses the disjuncture between a focus on university-industry interaction and community engagement, and how institutions can develop a more integrated and comprehensive approach.

Section Four then presents the principles of a framework and a differentiated approach to promote interactive capabilities.

SECTION ONE:

AN OVERVIEW OF THE SCALE AND FORMS OF INTERACTION BETWEEN UNIVERSITY AND INDUSTRY

The task of this section is to provide an overview of existing interaction between university and industry in South Africa, in effect, a broad map of interactive activity at present.

What proportion of academics in universities is interacting with firms, and who is more likely to do so? Section 1.1 analyses data from a 2010 survey of academics at five universities selected to represent the main institutional types in South Africa. It provides an indication of the scale of interaction with firms, in different types of university and knowledge fields.

A second concern is to identify the main forms of interaction we find in South African higher education. Section 1.2 presents a contextualised model of forms of interaction developed from an empirical study conducted across the national system in 2003/4 (Kruss 2005b, 2005b, 2006b). It then uses this model as a conceptual framework to analyse data from the survey, to illustrate the relative balance of forms of interaction typically found at present.

On the other hand, we may consider what proportion of firms is interacting with universities, and which firms are more likely to do so?

Section 1.3 draws on available national datasets, to show the extent to which firms are responding to government incentivisation schemes to conduct joint research with universities, and the extent to which innovating and R&D performing firms draw on universities as sources of information for their innovation and R&D activities, or cooperate with universities.

1.1 A WIDE SCALE OF ACADEMIC INTERACTION WITH FIRMS

The vast majority of academics at the five universities, 81% on average, reported that they interact with an external social partner in some way, on any scale (Table 1). This is a positive indication that academics generally view interaction with external social partners as desirable or an accepted aspect of their work.

TABLE 1: TOTAL NUMBER OF ACADEMICS WHO ENGAGE WITH EXTERNAL SOCIAL PARTNERS

Status	University					
	UoTech	Comp	Res2	Rural	Res1	Total
Engage	344 (74%)	272 (79%)	412 (93%)	150 (86%)	563 (76%)	1 741 (81%)
Do not engage	118	71	30	24	175	418
Total	**462**	**343**	**442**	**174**	**738**	**2 159**

Source: HSRC 2010 dataset

To what extent are these 1 741 engaged academics interacting with firms as partners? Three types of firm partners were identified - small, medium and micro enterprises (SMMEs), large South African firms, and multi-national enterprises (MNEs). Bearing in mind that a single academic may have multiple linkages, the majority or 58% of the engaged academics have some form of interaction with SMMEs, a close 56% had linkages with large South African firms and 42% with MNEs (Table 2).

The figure in brackets expresses these academics as a percentage of the engaged academics in that institution. Comparison across the five institutions reveals that the university of technology, the comprehensive university and the rural university had the highest share of academics interacting with SMMEs, while research university 2 had the highest share of large firms and MNEs. From another angle, few academics at the rural university interacted with MNEs, while double that number engaged with SMMEs.

TABLE 2: NUMBER OF ACADEMICS WHO ENGAGE WITH FIRM PARTNERS BY INSTITUTION

Firm partner	University type					
	UoTech	Comp	ResUniv1	RuralUniv	ResUniv2	Total
SMMEs	241 (70%)	170 (63%)	185 (45%)	90 (60%)	323 (57%)	1 009 (58%)
Large SA firms	201 (58%)	156 (57%)	203 (49%)	65 (43%)	343 (61%)	968 (56%)
MNEs	148 (43%)	120 (44%)	153 (37%)	42 (28%)	261 (46%)	724 (42%)
Engaged academics	**344**	**272**	**412**	**150**	**563**	**1 741**

Source: HSRC 2010 dataset

It is expected, as we found, that academics in Science, Engineering and Technology (SET) fields would interact with firms on a wider scale, but examination of the scale of activity in different knowledge fields with different types of firm partner also reveals counter-intuitive trends (Table 3). While one might expect more industry linkages in the fields of Business and Commerce, the number of linkages reported in the Humanities fields is very similar and quite surprising, as is the fact that they are more likely to be with SMMEs. Within the SET field, the largest share of linkages is with large local firms and SMMEs, but the scale of linkages with MNEs is considerable, highlighting an important new trend.

TABLE 3: TOTAL NUMBER OF ACADEMICS WHO ENGAGE WITH FIRM PARTNERS BY CESM CATEGORY

Partner	Knowledge field				
	Business and Commerce	Education	Other Humanities	SET	Total
SMMEs	183 (18.1%)	85 (8.4%)	184 (18.2%)	557 (55.3%)	1 009 (58%)
Large SA firms	166 (17.1%)	83 (8.6%)	157 (16.2%)	562 (58.1%)	968 (56%)
Multinational companies	127 (17.5%)	64 (8.8%)	115 (15.9%)	418 (57.8%)	724 (42%)
Engaged academics					**1 741**

Source: HSRC 2010 dataset

Thus, 81% of academics are likely to engage in some way, and just over half of these interact with SMMEs and/or large local firms, particularly but not solely in SET fields. The linkages counted here refer to a wide possible range of activities, forms and frequencies of interaction. One academic might be involved in a collaborative participatory research network with large and small firms, a science council, an industry association, and local government that entails weekly meetings.

Another academic might be generally educating graduates for the labour market with the right kinds of skills and attitudes through their teaching programmes and having no direct contact with firms, or perhaps in isolated instances through recruitment fairs or meetings. The following sections thus go on to consider the main forms of university interaction with firms in South Africa.

1.2 FORMS OF UNIVERSITY-INDUSTRY INTERACTION

1.2.1 A CONCEPTUAL MATRIX

How to characterize forms of university-firm interaction is widely debated in the literature, and the trend has been to develop typologies of practice in different national settings (Howells et al 1998, Charles and Conway 2001, Liefner and Schiller 2008). This report draws on a conceptual matrix developed out of an empirical study conducted in South Africa in the mid 2000s.

In a context of fiscal austerity and changes in state funding of universities from the late 1990s, there were pressures on South African institutions to become more financially self-sufficient.

Academic researchers and managers articulated a tension between an intellectual and a financial imperative shaping their interaction with industry. Many academics prioritized research that could be seen to make an intellectual contribution to their field or discipline, to academic reputation, and to the generation of knowledge for the future, but felt compelled to pursue partnerships with industry in order to ensure the financial sustainability of their research programmes, to fund laboratories or post-graduate students, or even to subvent their own salaries.

A similar tension existed within industry, whether firms prioritized research with a strong knowledge element that could lead to innovation that was new to the country or the world, or research to solve short-term problems and improve production incrementally.

An analytical matrix was constructed to represent the responses to this tension in the intersecting relationship between higher education and industry, which shaped the forms of partnership that resulted, represented diagramatically in Figure 1 (Kruss 2005a, 2005b). In effect, the matrix represents two intersecting continua, with the poles defined by the primarily financial or the primarily intellectual imperatives shaping the form an interaction will take. These are not either-or opposites, because in reality both operate simultaneously. As Castells (2001) argues about the contradictory functions of higher education, these poles represent resolutions of contradictions more strongly in favour of a particular imperative. Ideal types of the forms of partnership evident in South African universities were defined systematically and mapped onto this matrix, grounded in a large scale empirical study focused on key high technology sectors (Kruss, 2005a).

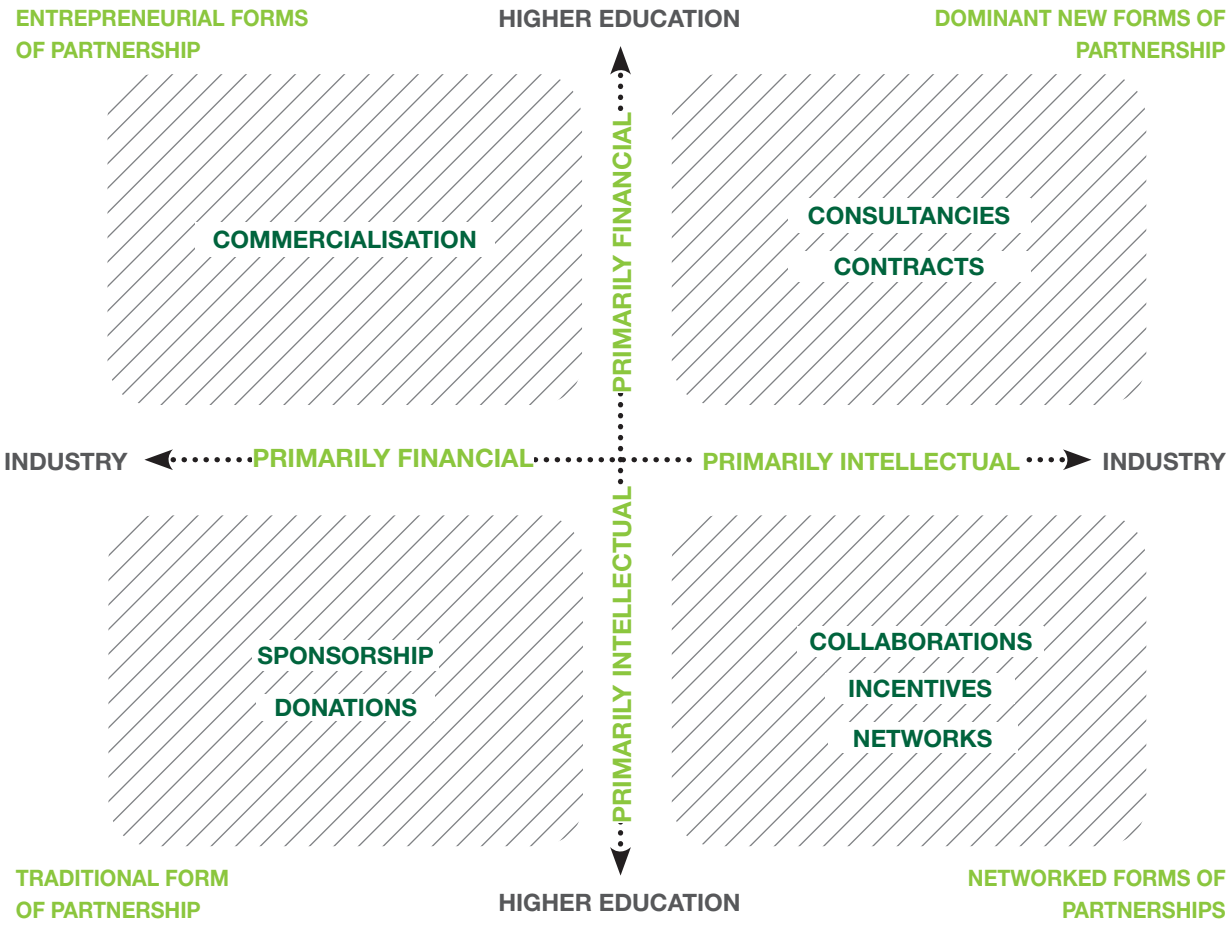

FIGURE 1. A CONCEPTUAL MATRIX OF FORMS OF UNIVERSITY-INDUSTRY INTERACTION IN SOUTH AFRICA

Traditional forms of partnership are long-standing and continue, in which industry essentially supports university academic work. Donations, one of the oldest forms of interaction, is conceptualized as benefaction or philanthropy on the part of industry, typically in the form of the endowment of a chair or building. Closely related is sponsorship, with post-graduate student research funding or student bursaries a core focus, given the imperative for industry to respond to socio-economic development needs. Funded students typically form a pool of potential employees for firms. Included here is interaction between firms and universities related to teaching, whether formal in terms of industry advisory curriculum advisory committees, or informal in that universities produce skilled graduates for the workplace for the professions and other high-skills occupations.

In these forms of interaction, the relationship between higher education and industry is primarily limited to a financial one, and higher education is left free to pursue its intellectual agenda, with few conditions imposed.

The dominant new forms of interaction evident across the higher education system at the time of the empirical research in 2003/4 were consultancies and contracts, strongly shaped by higher education's financial imperatives. In consultancies, typically an individual researcher in higher education acts in an advisory capacity to address the immediate knowledge problems of a firm, usually in exchange for individual financial benefit. The focus may also be short courses tailored to the specific training needs of firms. Likewise, contracts may be linked to solving potentially interesting scientific problems or, more likely, to addressing a specific immediate firm problem, but are primarily motivated by the need to attract funding for research on the part of higher education. Design solutions emerged where institutions with appropriate technological expertise set up centres for prototyping and testing, offering design solutions to industry. These forms of interaction place potentially severe restrictions on the intellectual agenda of researchers, in order to protect the financial interests of industry.

There was small but growing evidence of new entrepreneurial forms of partnership such as commercialization, in which higher education researchers take on a strongly entrepreneurial role, attempting to commercialize prior intellectual work in the form of a spin-off company or in collaboration with an existing company, willing to exploit intellectual property in the form of royalties, licences and patents, or through venture capital. Here, the relationship is primarily shaped by financial imperatives for both industry and higher education.

New networked forms of partnership have emerged, such as incentivized partnerships, with a weak form of intellectual collaboration, stimulated by government funding aimed at developing R&D and innovation. Collaborative interaction has a knowledge-based linkage in which all partners make an intellectual contribution. In a minority of instances, there is evidence of complex network forms of partnership, in the sense that they facilitate the acquisition of product design and production technology, enable joint production and process development, and permit generic scientific knowledge and R&D to be shared between a number of industry organizations and researchers from (several) higher education institutions (Castells 1996). These are knowledge-intensive forms of interaction and are primarily shaped by the intellectual imperatives of both industry and higher education partners.

The work of Cohen, Nelson and Walsh (2002) on the links between and impact of universities on firm R&D in the United States, has been influential in shaping a body of research in developing countries that can refine and build a more theoretically robust analytical frameworkm, that confirms and deepens this empirically derived conceptual matrix.

Cohen et al's framework emphasised the fields and sectors, channels, outcomes and benefits of interaction with universities. This approach was first adapted to frame survey research on the nature of interaction between universities and firms in the Minas Gerais region of Brazil (Albuquerque et al, 2008; Rapini et al, 2009). It was subsequently adapted to study the nature and patterns of university industry interaction in selected sectors in twelve developing countries in Latin America, Asia and Africa (Adeoti et al, 2010; Arza and Vazquez, 2010; Dutrenit, Du Fuentes and Torres, 2010; Eom and Lee, 2009; Eun 2009; Fernandes et al, 2010; Intarakumnerd and Schiller, 2009; Joseph, 2009; Orozco and Ruiz, 2010; Rasiah, 2009).

The Latin American work was seminal in conceptually linking specific channels with the associated benefits and risks of interaction in developing country contexts (Arza, 2010; Arza and Dutrenit, 2010). The conceptual framework drew on the South African matrix of types of interaction presented in Figure 1, but developed it more systematically in relation to the research literature, and tested it through econometric analyses of data from a survey of firms and universities in each of four countries. Channels of interaction were classified into four broad types, distinguished by the combinations of goals that motivate firms (passive or proactive innovation strategies) and universities (economic [financial] or intellectual strategies) to interact. Interaction motivated by the economic strategies of universities and passive strategies of firms is more likely to take the form of 'service' channels, whether scientific or technological, where knowledge flows mainly from the university to the firm. Examples are consultancy or testing or quality control. This is akin to 'newly dominant' forms in Figure 1. In contrast, interactions motivated by the intellectual strategies of the university and proactive strategies of firms are more likely to take 'bi-directional' forms, where knowledge flows are two-way and there is a high potential for joint learning. Examples are joint R&D projects or networks, akin to 'network' forms of interaction in Figure 1.

'Traditional' forms of interaction are driven by the intellectual imperatives of the university and the passive strategies of firms, with knowledge flows to firms but defined strongly by academic functions, such as hiring graduates, conferences and publications. They may also take the form of financial flows from firms to support the academic function, such as endowments of facilities or chairs or scholarships. These channels are indirect, in that they are available freely in the public realm, and do not require a personal exchange.

Finally, 'commercial' forms of interaction are driven by the economic strategies of universities and the proactive strategies of firms, taking the form of spin-off companies or incubators that, like the bi-directional channels, require direct personal interaction, at critical stages. These are akin to 'entrepreneurial' forms of interaction in Figure 1.

This conceptual matrix was used to analyse the survey data on South African academics current interaction with firms.

1.2.2 EMPIRICAL EVIDENCE OF TYPES, CHANNELS, OUTCOMES AND BENEFITS

A widely held and negative perception of university-industry interaction is that it relates to research consultancy and commercialization – to the marketisation of higher education - which can undermine the academic intellectual project.

The data shows a very different picture, in that much of the reported activity relates to core university teaching and learning activities. Academics were asked whether they extended their academic expertise to the benefit of external social partners, and only those who indicated that they interacted with firms were included in the analysis here.

Most academic linkages with industry partners takes traditional forms (Table 4), particularly related to core teaching activities, whether taking the very general, informal and indirect form of 'education of socially responsive students' and 'alternative modes of delivery', or the more direct and structured interaction of work integrated learning, other forms of student experiential placement, or continuing professional education. The service forms of research consultancy and customized training were evident on a larger scale than were research contracts. The related forms of policy research and expert advice can help explain the large number of linkages in the fields of Business and Commerce, and Humanities. Network forms also exist, but with fewer linkages with large local firms, a trend that bears further investigation. Entrepreneurial forms of interaction in fact occur on the smallest scale, especially commericialisation, and especially with large local firms. In fact, the pattern of interaction with MNEs is somewhat counter-intuitive, with the highest number of 'collaborative curriculum design' linkages, and high numbers of network forms of interaction.

TABLE 4: TOTAL NUMBER OF LINKAGES WITH FIRMS BY TYPE OF RELATIONSHIP

Form of interaction	Type of relationship	SMMEs	MNE	Large firms
Traditional	Alternative modes of delivery to accommodate non-traditional students	785	570	752
Traditional	Work-integrated learning	858	625	578
Traditional	Education of students so that they are socially responsive	**942**	675	**900**
Traditional	Service learning	740	536	706
Traditional	Student voluntary outreach	686	485	659
Network	Collaborative curriculum design	840	**846**	814
Traditional	Continuing education or professional development	905	662	881
Dominant	Customised training and short courses	806	596	773
Dominant	Policy research, analysis and advice	671	509	671
Dominant	Expert testimony	558	411	531
Traditional	Clinical services and patient or client care	243	340	260
Dominant	Design and testing of new interventions or protocols	593	456	587
Dominant	Design, prototyping and testing of new technologies	567	465	575
Dominant	Monitoring, evaluation and assessment	801	588	771
Dominant	Research consultancy	839	622	824
Entrepreneurial	Technology transfer	675	506	262
Dominant	Contract research	606	488	251
Network	Collaborative R&D projects	784	592	316
Network	Community-based research projects	677	486	295
Network	Participatory research networks	754	554	303
Entrepreneurial	Joint commercialization of new product	331	268	139

Source: HSRC 2010 dataset

In order to understand the nature of interaction more fully, it is important to examine the channels through which the process of interaction is facilitated. There were 19 channels of interaction identified, but the most frequent channel used by academics in relation to firms was informal information exchange (Table 5). Public conferences, seminars or workshops were the second most frequent channel for large SA firms and SMMEs, followed by the students that graduate. Interaction through channels linked to the dominant new forms such as training, reports and oral advice was widespread. Fewer academics engage in wider public dissemination through the media or websites however.

A small number of academics indicated engagement through channels such as network forms of technology networks, incubators and entrepreneurial forms such as spin-off firms, patents and other channels that require direct, formal and knowledge intensive engagement. So, for the most part, interaction takes place informally, indirectly and through knowledge that is freely available in the public domain, or 'walking on feet'.

TABLE 5: TOTAL NUMBER OF ACADEMICS WHO ENGAGE WITH FIRMS BY CHANNEL OF RELATIONSHIPS

	Large firms	SMMEs	MNEs
Public conferences, seminars or workshops	924	956	695
Informal information exchange	941	985	704
Radio, television or newspapers	522	515	395
Popular publications	685	686	512
Interactive websites	641	656	495
Students	906	941	676
Reports and policy briefings	726	743	558
Oral or written testimony or advice	838	883	633
Training and capacity development	858	881	656
Demonstration projects or units	619	642	472
Research contracts and commissions	612	584	476
Technology incubators or innovation hubs	245	380	297
Intervention and development programmes	591	612	452
Software development or adaptation for social uses	282	298	238
Participatory or action research projects	666	670	504
Cross-disciplinary networks	720	754	533
Technology development and application networks	460	591	379
Patent applications and registration	205	217	173
Spin-off firms from the university (commercial or not for profit)	283	299	229

Source: HSRC 2010 dataset

Many academics are concerned that interaction with firms will have a negative impact on their academic productivity and hence, reputation. The data shows significant trends to confound this fear. 'Typical' academic outputs such as 'graduates with the right skills and values', academic publications or dissertations were most frequently reported, while typical firm outputs, such as new or improved products and processes, were least frequent. 'Graduates with the right skills and values' was the most frequent output for both large SA firms and SMMEs, while for MNEs, academic collaboration was the most common result of interaction. This might suggest that the types of outputs from academic engagement with firm partners are more beneficial to academic institutions and academics than they are for firm partners.

The most common output that is not traditionally academic was reports or popular publications, which are closely aligned with extending and applying academic expertise. New or improved processes were more frequently reported than new products or scientific discoveries, which illuminates the nature of university involvement in firm innovation processes. Spin-off companies were more commonly reported as an output of interaction with MNEs, which is more than likely related to the lack of venture capital in South Africa, and the need to access larger global markets.

TABLE 6: TOTAL NUMBER OF ACADEMICS WHO ENGAGED WITH FIRMS BY OUTPUTS

	Large Firms	SMMEs	MNEs
Graduates with relevant skills and values	930	963	691
Academic publications	862	862	653
Dissertations	812	814	616
Reports, policy documents and popular publications	756	766	576
Cultural artefacts	243	263	183
Academic collaboration	901	925	**677**
Spin-off companies	253	277	448
Community infrastructure and facilities	460	488	355
New or improved products	457	481	370
New or improved processes	671	682	520
Scientific discoveries	433	428	344

Source: HSRC 2010 dataset

The trend is confirmed when the analysis is extended to the outcomes and benefits of interaction with firms, with the most frequent for large firms and SMMEs being improved teaching and learning while for MNEs, intervention plans and guidelines were the most frequent (Table 7).

The outcomes and benefits that are more 'academic' such as academic and institutional reputation, or theoretical developments in a field were more frequent than those that are 'firm' related such as firm productivity or employment generation.

TABLE 7: TOTAL NUMBER OF ACADEMICS WHO ENGAGE WITH FIRMS BY OUTCOMES AND BENEFITS

	Large firms	SMMEs	MNEs
Public awareness and advocacy	845	879	626
Improved teaching and learning	**945**	980	701
Community-based campaigns	633	666	487
Policy interventions	603	617	457
Intervention plans and guidelines	660	678	721
Training and skills development	894	934	670
Community employment generation	524	566	403
Firm employment generation	542	574	436
Firm productivity and competitiveness	580	611	474
Novel uses of technology	595	621	467
Improved quality of life for individuals and communities	795	833	598
Regional development	606	630	449
Community empowerment and agency	638	673	474
Incorporation of indigenous knowledge	569	598	427
Participatory curriculum development	820	843	614
Relevant research focus and new research projects	897	906	676
Academic and institutional reputation	911	946	692
Theoretical and methodological development in a field	884	916	665
Cross-disciplinary knowledge production	772	794	572

Source: HSRC 2010 dataset

Is there a difference in outcomes and benefits in distinct knowledge fields? Three main firm-related outcomes and benefits were analysed, revealing that academics in the SET fields had a larger number of academic linkages that resulted in firm employment, firm productivity and novel uses of technology (Table 8). The largest single set of linkages on the part of academics in the SET fields with SMMEs or large firms resulted in novel uses of technology.

As a contrast, outcomes and benefits related to social development were analysed. The most common benefit was improvement in the quality of life, followed by regional development (Table 9). More academics in the Education and Humanities fields reported these outcomes than did firm-related outcomes, but those in SET were more likely to report social development related outcomes, and this was clearly alongside firm-related outcomes.

TABLE 8: ACADEMICS WHO ENGAGED WITH FIRMS BY FOUR CESM AND MAIN FIRM-RELATED OUTCOMES AND BENEFITS

	Firm employment			Firm productivity			Novel uses of technology		
	Large firms	SMMEs	MNEs	Large firms	SMMEs	MNEs	Large firms	SMMEs	MNEs
Business and Commerce	**107**	**109**	**83**	**110**	**113**	**93**	**92**	**99**	**75**
Education	45	45	38	53	50	44	50	49	37
Other Humanities	87	105	72	87	107	69	84	101	63
SET	**303**	**315**	**243**	**330**	**341**	**268**	**369**	**372**	**292**
Total	**542**	**574**	**436**	**580**	**611**	**474**	**595**	**621**	**467**

Source: HSRC 2010 dataset

TABLE 9: ACADEMICS WHO ENGAGED WITH FIRMS BY FOUR CESM AND THREE MAIN SOCIAL DEVELOPMENT OUTCOMES AND BENEFITS

	Policy interventions			Improved quality of life			Regional development		
	Large firms	SMMEs	MNEs	Large firms	SMMEs	MNEs	Large firms	SMMEs	MNEs
Business and Commerce	100	105	79	133	143	101	110	113	81
Education	65	63	48	76	77	59	62	60	46
Other Humanities	111	124	84	137	165	102	104	118	75
SET	**327**	**325**	**246**	**449**	**448**	**336**	**330**	**339**	**247**
Total	**603**	**617**	**457**	**795**	**833**	**598**	**606**	**630**	**449**

Source: HSRC 2010 dataset

Clearly, different institutional types of universities display distinctive patterns of interaction, as do academics in different knowledge fields, and with partners in different types of firm. These distinct patterns may be analysed in detail, for more nuanced insight to inform an institution's strategies.

For our purposes here, however, it is sufficient to draw out the strongest aggregative trends that emerge from the analysis of the practices of academics at these five universities:

1. Academics are interpreting the imperative to engage with external social partners very broadly, and closely linked to their core work of teaching and research.
2. Approximately half of all academics indicated that they interact with firm partners, the majority with SMMEs and large local firms, and an important emergent trend is interaction with MNEs.
3. Academics in all knowledge fields, not only SET are interacting with firms, and there are a similar number of linkages reported by academics in Business and Commerce, and the Humanities fields.
4. The type of relationship tended to take traditional forms related to teaching, and may involve sponsorship and funding from firms to the university.
5. Research related newly dominant forms are consultancy, expert advice and contracts, while there are emergent network forms of interaction and fewer entrepreneurial forms evident.
6. The channels of interaction are generally informal, indirect and not knowledge intensive.
7. The outputs tend to be traditionally academic related and typically 'walking on legs'.
8. The outcomes and benefits tend to favour academics rather than firms, although social development related outcomes are also prevalent.

It is useful for institutional management and leadership to understand these general trends, and to analyse further the patterns of academic practices in distinct types of university or knowledge fields, as a basis for developing policy, strategy and mechanisms to build interactive capabilities.

However, understanding what academics currently do provides only one perspective on how interaction can be promoted, that needs to be complemented by the perspective of firms, and what they demand from universities – the focus of the next section.

1.3 FIRM DEMAND FOR UNIVERSITY KNOWLEDGE AND TECHNOLOGY

In the early years of development of the national system of innovation after 1994, there was a great deal of enthusiasm on the part of university research and innovation managers to put in place institutional mechanisms to promote interaction with firms, drawing on the models of universities in developed economies, particularly the UK or US. There was insufficient awareness of the nature of firm demand - to what extent do firms draw on university knowledge and technology to inform their innovative and R&D activities, and which firms are more likely to do so? Analysis shows that globally, universities are less important partners for firms' innovative activities than are suppliers, customers or firms within their group, but that R&D performing firms are more likely to collaborate with universities to meet their knowledge and technology needs (Frenz and Ietto-Gillies 2009, Berger and Diez 2006). If universities develop their own institutional strategies without understanding global, national or regional firm demand, spectacular failures may result. There are instances of ambitious science parks, regional incubators or institutional enterprises that failed in South Africa, largely because of a lack of strategic intelligence on firm demand and on local and global markets.

The focus of this section is to analyse interaction with universities from the perspective of South African firms, investigating which firms seek to cooperate with universities and why, in order to inform a more comprehensive understanding of the ways in which universities can meet the needs of firms.

1.3.1 GOVERNMENT INCENTIVISATION OF UNIVERSITY-FIRM INTERACTION

In the late 1990s, government established funding schemes that aimed to incentivize technological advancement and innovation through the promotion of collaboration between firms, universities and science councils to ensure multi-institutional and multi-sectoral cross-transference of technological knowledge. The Technology for Human Resources and Innovation Programme (THRIP) and Innovation Fund schemes aimed to advance research, human resource capacity and technology outputs in science, technology and engineering fields, in order to improve the competitiveness of South African industry.

The projects funded under these schemes typically entail service or network forms of interaction, involving firms, universities and often, SETIs or other firms as partners on R&D and technology development.

The THRIP grant scheme in particular has been extremely successful in promoting university-firm interaction (HSRC 2003, Letseka 2005). It focuses on the pre-commercial stage of research. THRIP forces collaboration between industry and academia, making sure that they both contribute. Firms and THRIP can invest jointly, requiring a leader from a higher education institution. Alternatively THRIP can match the investment of industry where project leaders are researchers/ experts from Science, Engineering and Technology Institutions (SETIs) and students registered at a higher education institution must be trained through the project. There is also a Technology Innovation Promotion through the Transfer of People (TIPTOP) scheme to place graduates in industry for training, and allow for the exchange of researchers and technology managers between SETIs and HEIs (THRIP 2011).

The data suggests that in 2008/9, almost 190 SET research teams across the 23 universities interacted with firms in research partnerships (Appendix 2). The firms involved in THRIP projects tend to be based in the primary sector, focusing on agricultural research. In addition, projects focusing on energy, ICT, biotechnology and minerals and metals research were allocated a significant amount of funding compared to tourism and automotive industries.

Of the R138,9 million contributed by THRIP, SETIs were awarded R11,8 million and the lion's share went to the universities (Appendix 2). Firms are required to match THRIP funding in various ways, so have a strong motivation for interacting with universities, whether in relation to human resources, new or improved processes or products.

Two trends stand out that suggest the impact of THRIP for promoting university interaction across the higher education system is increasingly limited. First, funding still tends to be concentrated at large historically advantaged research universities with strong SET capacity. For instance, in 2008/9 R100,5 million was released to universities, universities of technologies received R18,8 million and comprehensive universities received R7 million (Appendix 2). Disaggregating further to consider the group of 11 universities, only a few universities received the bulk of the funding: the University of Pretoria and Stellenbosch University dominated with 40 projects each, University of Cape Town 31 and University of Witwatersrand 22 (Appendix 2). Likewise, the University of Cape Town was a major contributor to the total journal outputs, closely followed by Stellenbosch University and University of Pretoria, while Witwatersrand University recorded the highest number of patents in 2008.

Second, the total available for THRIP funding has declined from 2000/1 when 413 projects were funded to the tune of R137.5 million (at 2001 Rand values), to 2008/9 when 240 projects were funded to the tune of R138,9 million (at 2009 Rand values) (HSRC 2003, THRIP 2009). Likewise, the number of outputs from collaboration, particularly scientific publications and patents, has declined (Table 10). However, the outputs from these forms of service and network interaction are considerable, especially in academic terms.

TABLE 10. THRIP OUTPUTS 2006-2008

	2006	2007	2008
Patents	30	30	19
Publications	1,697	1,780	1,151
Students	3,014	2,054	1,971
Number of researchers	744	1,011	942
Funding- Universities		105,394,860	R100, 515 ,689

Source THRIP 2009

The universities and firms interacting through THRIP support represent a core but limited and potentially declining segment of the total national university-firm interaction. To obtain a view of the practices of firms in general, evidence from national innovation and R&D surveys is analysed.

1.3.2 INNOVATING FIRMS AND UNIVERSITIES

Without highly educated and skilled staff, firms are less likely to innovate, a key role of universities that is not directly measured in innovation surveys. Rather, the data focuses on the partners and sources of information for firms' innovative activity, on the more direct research oriented forms of interaction.

In general, just over half of South African firms, 52%, report innovative activity. Of course, there are various ways of innovating – process or product, incremental or radical, new to the firm, the country or the world – and the potential role of universities differs accordingly. The type of innovative activity reported was predominantly investment in the acquisition of new capital equipment (54% of innovative firms) to ensure that process improvements are in place to increase productivity.

Such process innovation is based on learning by doing and continuous incremental improvement and tends to involve R&D to a lesser extent than product innovation (Lorentzen et al 2010). Just over half of innovating firms (52%) indicated that they conduct R&D in-house. Some 28.3% of innovative firms engaged in the acquisition of other external knowledge such as the purchase or licensing of patents. Only 19.3% engaged in extramural or outsourced R&D, including from other firms in a group or from universities (Blankley and Moses 2005). The pool of firms that conduct the kind of innovation that requires direct interaction with universities around R&D (whether in the form of a consultancy, contract or collaborative network) is thus small.

How important are knowledge factors in explaining why some firms do not innovate? These firms cited market factors, lack of funds, lack of demand and the costs of innovation as the most significant constraints. Lack of qualified personnel was also a major constraint, even for innovative firms. Difficulty in finding cooperation partners posed more of a challenge to non-innovating firms (Table 11). Knowledge factors – and university's contribution – could thus make a difference in facilitating innovation activities for some firms.

TABLE 11: FACTORS HAMPERING INNOVATION ACTIVITIES OF ALL ENTERPRISES 2002-2004

	Industry	Services	Total	Innovative	Non innov
Cost factors					
Lack of funds within enterprise or group	26.0%	24.8%	25.3%	29.1%	21.3%
Lack of finance from external sources	16.6%	14.4%	15.4%	18.7%	11.9%
Innovation costs too high	18.1%	22.2%	20.4%	22.8%	17.7%
Knowledge factors					
Lack of qualified personnel	16.9%	16.9%	17%	20.4%	13.2%
Lack of information technology	8.3%	1.0%	4.3%	3.5%	5.1%
Lack of information on markets	5.2%	2.8%	3.8%	3.3%	4.4%
Difficulty in finding cooperation partners	11.2%	5.6%	8.1%	4.0%	12.5%
Market factors					
Market dominated by established firms	20.5%	30.7%	26.2%	23.2%	29.2%
Uncertain demand for innovative goods	6.5%	12.6%	9.9%	9.5%	10.3%
Reasons not to innovate					
No need due to prior innovations	5.1%	3.3%	4.1%	3.0%	5.2%
No need because of no demand for innovation	4.3%	12.9%	9.0%	0.7%	18.0%

Source: SAIS (2005)

For the most part, innovative firms do not rely on universities directly, indicating that they co-operate with and interact closely with local clients and customers, or suppliers and competitors (Table 12), but in comparison with international trends, South African firms do report a relatively high degree of active cooperation with local universities and technikons – 15% of innovative firms.

Foreign firms are more innovative and more likely to cooperate with other partners, but domestic firms are more likely to cooperate with universities - only 5% of foreign-owned firms cooperate with local universities, in contrast to 16% of domestic firms.

TABLE 12: COOPERATION FOR INNOVATION BY TYPE AND LOCATION 2002-2004

	South Africa	Rest of Africa	Europe	USA	Asia	Other
Clients and customers	36.8%	4.2%	2.0%	1.1%	0.9%	1.0%
Suppliers of equipment, material, components or software	29.7%	0.7%	8.6%	3.3%	0.4%	2.7%
Competitors or other enterprises in your sector	29.1%	0.6%	2.5%	2.2%	2.9%	0.3%
Other enterprises within your group	4.0%	0.2%	3.7%	3.4%	0.5%	0.2%
Consultants, commercial labs or private R&D	17.9%	0.1%	1.0%	0.5%	0.2%	0.3%
Universities or technikons	15.4%	0.05	0.6%	0.4%	0.0%	0.2%
Government or public research institutes	13.2%	0.1%	0.4%	0.3%	0.0%	0.2%

Source: SAIS (2005)

Universities may be a less direct source of information for firms, in the publicly available forms of conferences, journal articles or other media, knowledge that makes innovation possible. This is not frequently the case. Only 5% of innovative firms indicated that universities are highly important sources of information. Almost all of the innovative firms in both the industrial and services sectors source the information they need within the enterprise itself, relying on in-house innovative capabilities and resources (Table 13 below). External firm sources such as clients and suppliers are important, but local universities are not. Other professional and industrial associations are more important sources of information than knowledge generating institutions.

In order to establish which firms are more likely to interact with universities, a sub-sample was extracted from the Innovation survey dataset. Of 264 firms that cooperate on their innovation activities, 108 reported that they interact with SA universities (Table 13). Firm size seems to be associated with the propensity to cooperate with universities, in that these are mainly large (38%) or medium (33.3%) enterprises, and only a few small enterprises. They have a higher number of staff members (who tend to be highly educated), than those who do not collaborate with universities. There appears to be a distinct sectoral difference in the proportion that the university-collaborating firms contribute to total turnover, relative to the contributions of firms that do not cooperate with universities, and those that do not cooperate at all. The proportion of turnover contributed was largest by firms that collaborate with universities in the manufacturing sector (52%), followed by those in mining (24,5%), wholesale and retail (10.6%) and financial and business (7,6%) sectors.

The propensity to collaborate with a university is associated with higher levels of R&D intensity in a firm. The firms cooperating with universities spend a significant amount on in-house R&D to intensify their knowledge capacity (Table 13), twice as much as those with no university cooperation partners. This suggests that these firms are looking to universities to complement their existing R&D capacity.

TABLE 13: COMPARISON OF FIRMS THAT COLLABORATE WITH UNIVERSITIES OR NOT

	Total samplem (N=607)		Collaboration (N=264)		University collaborations (N=108)		Non-university collaborators (N=156)	
	Yes	No	Yes	No	Yes	No	Yes	No
In-house R&D	396	211	202	62	85	23	117	39
Outsourced R&D	230	375	147	117	79	29	68	88
Acquisition of other external knowledge	200	406	119	145	60	48	59	97
Innovation expenditure (in 000 Rands)								
Total	**7,000,475**		**5,488,225**		**2,927,408**		**2,560,817**	
In-house R&D	1,595,530		1,386,322		964,289		422,033	
Outsourced R&D	688,703		570,399		329,663		240,736	
Acquisition of capital equipment	4,147,716		3,047,470		1,375,334		1,672,136	
Acquisition of other external knowledge	570,526		484,034		258,122		225,912	

Source: SAIS (2005) unweighted dataset, CeSTII

There are sectoral differences, in that firms in the manufacturing sector are more likely to interact with external partners and with universities specifically. Firms in the services sectors reported lower levels of interaction in general and with universities (Table 14).

TABLE14: INNOVATION AND INTERACTION BY SECTOR

	Total number of firms	Innovating firms	Innovating firms with interaction	Interaction higher education
Total number of firms	**981**	**603**	**264**	**108**
Manufacturing	367	266 (72.5%)	133 (36.2%)	59 (16.1%)
Financial and business services	146	84 (57.5%)	36 (24.7%)	14 (9.6%)
Mining	45	24 (53.3%)	11 (24.4%)	5 (11.1%)
Wholesale and retail	320	166 (51.9%)	54 (16.9%)	26 (8.1%)

Source: Innovation Survey 2005 dataset (unweighted)

1.3.3 R&D PERFORMING FIRMS AND UNIVERSITIES

Firms that perform R&D may be expected to collaborate directly with universities on a wider scale than firms in general, which was investigated through analysis of a set of national R&D survey datasets from 2004-2008.

In contrast to innovating firms, local universities are indeed key collaborative partners for R&D performing firms, the most common partner, followed by other firms (including specialist consultancies) (Table 15). International partners are more likely to be other firms than universities, although there is a small steady set of international university partners over the period.

TABLE 15: R&D COLLABORATION BETWEEN SA AND FOREIGN INSTITUTIONS 2004-2008

Partner	2007/08		2006/07		2005/06		2004/05	
	South Africa	Foreign	South Africa	Foreign	South Africa	Foreign	South Africa	Foreign
Higher education institutions	92	23	85	23	120	31	100	23
Science Councils	18	5	19	12	82	16	66	9
Government research institutes	24	17	31	13	43	14	22	9
Members of own company/Affiliated	38	12	55	14	83	54	65	40
Other companies (specialist consultants)	80	35	175	20	99	62	81	47
Not-for-profit organizations	17	2	19	4	15	4	5	3
Total	269	94	384	86	442	181	339	131

Source: R&D Surveys 2004-2008

Interaction is more likely in specific sectors and in relation to specific research fields. More firms in the manufacturing sector are likely to collaborate with universities (60%) than in the financial and business service sectors (47%), but the latter sector tended to have a higher level of R&D activity, and included several 'big spenders' on R&D. The expenditure of R&D performing firms tends to be concentrated in engineering sciences and ICT, high technology fields that require highly skilled graduates, a possible channel of interaction with universities (Table 16).

TABLE 16: R&D EXPENDITURE BY RESEARCH FIELD

	2005/06	2006/07	2007/08
ICT	1,635,321	1,980,630	2,182,253
Engineering sciences	2,219,530	2,439,092	3,237,265
Medical&Health sciences	1,073,854	1,225,114	1,268,551
Applied sciences and technologies	1,384,945	1,551,885	1,581,438
Social Sciences	323,673	360,856	380,554
Humanities	359	405	469
Other Sciences	1,606,094	1,685,183	2,087,926
Total	**8,243,776**	**9,243,165**	**10,738,456**

Source: R&D Survey 2008

The nature of the R&D performed shapes the demand for and the types of relationship firms will have with universities. Over the years, firms have increasingly dedicated a larger share of their R&D expenditure to experimental research in contrast to applied and basic research (Table 17). Experimental research can easily be transformed into saleable products enabling profit and revenue generation.

TABLE 17: TYPE OF RESEARCH CONDUCTED BY FIRMS

	2004/05	2005/06	2006/07	2007/08
Basic research	9,5%	8,7%	8,7%	8.7%
Applied research	32,9%	29,2%	27,6%	28,7%
Experimental research	57,6%	62,0%	63,8%	62,7%

Source: R&D Survey 2008

Generally, firms that do not collaborate with universities conduct the highest proportion of experimental research (Table 18). Firms that interact with universities tend to conduct more basic and applied research, particularly those in the manufacturing and financial and business sectors.

TABLE 18: R&D EXPENDITURE BY TYPES OF RESEARCH (MEAN %) [1]

	Firms collaborating with universities	Firms not collaborating with universities	Firms not collaborating at all
Agriculture			
Basic research	6.1%	2,5%	
Applied research	36.3%	21.8%	
Experimental research	57.6%	80.6%	
Mining			
Basic research	9.9%	0.0%	
Applied research	37.0%	89.3%	
Experimental research	54.1%	14.3%	
Manufacturing			
Basic research	16.5%	7.8%	10.6%
Applied research	38.4%	37.9%	27.4%
Experimental research	59.2%	74.3%	76.5%
Financial and Business Services			
Basic research	23.1%	14.8%	26.8%
Applied research	38.1%	39.7%	47.2%
Experimental research	54.2%	60.0%	79.5%

Source: R&D survey (2005/6) unweighted dataset, CeSTII

A sub-sample of R&D performing firms that collaborate with universities only, and not other partners as well, was constructed to provide a better view of the contribution of universities to firms' activities. These firms were more likely to be high technology firms in the manufacturing sector, which placed greater importance on experimental research (75.6%) than those that collaborate with partners other than universities (66.8%). Universities often have facilities for experimental research such as fully equipped laboratories and expertise that firms may not have in-house. This group of firms had considerably lower levels of R&D activity, with a mean R&D expenditure less than half that of the group that collaborate with other partners, as well as a smaller number of R&D personnel. In addition, nearly a third of the group were micro-firms (probably university spin-off companies), and the largest proportion of firms was small firms, in contrast to the high proportion of large firms in the group with no university collaborative partners. Taken together, this may imply that these small firms approach universities to complement or substitute where they lack R&D capacity.

1.3.4. UNDERSTANDING FIRM DEMAND AND PROPENSITY TO INTERACT

Firms are motivated to interact with firms on their R&D and innovation activities when there is public sector funding as an incentive, but they typically prefer to interact with a few universities that have a reputation for research productivity and quality.

In general, there is not a high demand for knowledge from, or direct cooperation with, universities on the part of most innovating firms in South Africa, but there is a stronger demand from the smaller set of R&D performing firms. If we aggregate, the strongest trend evident is that those firms that interact with universities are more likely to be to be large firms in the manufacturing sector, research intensive, seeking complementary capacity. More firms tend to cooperate with universities on their R&D activities, also primarily in the manufacturing sector, and there is a group of small firms that seek to substitute for missing experimental R&D capacity from universities.

The analysis has attempted to illustrate that such a dataset is extremely useful to universities. Interaction is more commonly initiated when industry comes forward with a problem, and universities are used for their expertise to solve that problem. Less commonly, academia will present an opportunity, and propose collaboration to industry. Understanding firm demand is thus critical.

The datasets can be mined further to disaggregate rather than analyse commonalities, in order to identify the propensity of different types of firms in specific sectors, with different R&D intensities and with different levels of technology, to collaborate with universities and other partners in relation to specific types of research. The analysis highlights the distinct patterns of interaction of firms in different sectors, and hence, the significance of understanding sectoral dynamics. These datasets provide an important source of information for universities to understand firm demand and how to focus their efforts to maximum effect.

1. Note that firms may conduct more than one kind of research, hence the totals do not add up to 100% in each sector, but represent the proportion of firms in that sector.

SECTION **TWO:**

COORDINATION AND ALIGNMENT ACROSS THE NATIONAL SYSTEM OF INNOVATION

The next step, in order to further elaborate on 'what exists' as a basis for developing a framework, is to move beyond mapping the scale and forms of interaction between universities and firms, to consider the policy and institutional conditions that facilitate or constrain interaction and the benefits and risks involved.

Section 2.1 presents a set of cases that highlight the need for more effective coordination and alignment between the organizations and actors within the national system of innovation, if interaction is to have successful outcomes for universities, firms, technological upgrading and competitiveness.

Section 2.2 considers recent shifts and development in the national policy framework for higher education, science and technology and economic development that have important implications for the promotion of university-firm interaction.

2.1. THE SIGNIFICANCE OF COORDINATION AND ALIGNMENT ACROSS THE NSI [2]

Entrepreneurial or commercialisation forms of interaction are widely debated and contested, particularly the desirability of university spin-off companies. Many universities aspired to create their own spin-off companies over the past decade. Such commercialization of knowledge is facilitated by the South African science and technology policy framework, and by a range of government initiatives including funding programmes, technology incubators in key sectors, and 'technology stations' focused on SMMEs at the universities of technology.

The research literature suggests that, in general, starting or creating a high-technology company may be possible for university-based academics. However, sustaining and growing a successful spin-off company over an extended period is a major challenge (Franklin et al, 2001; Wright et al, 2006, Pries and Guild, 2007; Mustar et al, 2006).

Knowledge intensification requires strong institutional networks to support increased knowledge diffusion across national systems of innovation.

Despite the encouraging trends in South Africa, there is concern that such institutional networks are not yet sufficiently developed in the national system of innovation (OECD, 2007).

In November 2003, eleven case studies of 'technology cooperation networks' were conducted to understand their creation, structure and dynamics (Kruss, 2006a, 2006b). Three cases were selected for follow-up in August 2007. The cases were in the ICT sector (broadly defined), focused on innovation of product and oriented towards a specialized niche, high-technology customer base. The most 'classic' ICT case was a software development network centred on a virtual reality authoring tool. A second case was a bioinformatics network at the cusp of biotechnology and ICT, established to develop tools to analyse the human genome. The third case merged the communications technology subsector and space science to develop an imager for a micro-satellite.

In general, analysis of these networks over time suggests that the intellectual capacity to develop cutting edge high-technology products exists, and that there is a degree of entrepreneurial and interactive capability in universities that can create spin-off firms. However, the empirical analysis shows that, despite a favourable policy and funding context, it is extremely complex to sustain a competitive knowledge-intensive university spin-off firm in South Africa. The three cases illustrate a continuum of challenges: the software development case illustrated the failure to create a spin-off, the bioinformatics network illustrated the failure to sustain a spin-off, and the imager network illustrated the challenge to remain competitive.

2 This section draws on Kruss 2008b

The software development case illustrated a misalignment between the software sector and the national technology system (the structures and networks of government, education systems and public research institutes) and within the national technology system, which shaped the failure to proceed to commercialization (see Von Tunzelmann 2007). A lack of common goals between the research group and firms in the ICT software subsector, reputation-related competition between research groups based at different universities and science councils, and a lack of interactive capability on the part of the project leader led to network failure at an early point. The functional networks and human and capital resource flows that could bring the macro- and micro-levels of innovation and production together were not present. Numerous attempts to build new links with other firms and to strengthen existing links with government funding agencies and within the university failed to create conditions to support the ongoing R&D required to proceed towards commercialization.

In contrast, conditions of alignment within the national technology system were more extensive and supported the creation of bioinformatics and satellite spin-off firms. However, in these cases interlocking complementarities in geographical networks (particularly the coordination of marketing activities at the global level) were absent, exacerbated by weak interaction in the functional and resource networks of the firm and of government. For the bioinformatics firm, misalignment of the firm in relation to the national market and the global demand for bioinformatics, and ineffective coordination of the managerial networks within the firm itself meant that the company was left vulnerable to disruption of the capital resource flow networks it required to put a new business strategy in place.

The satellite firm had strong internal alignment of its functions and management, and it had good knowledge resource flows with the university. However, a major misalignment in its supplier value chain impacted on its ability to access global markets, and its competitiveness. Its goals were in strong alignment with government goals and strategic priorities, which meant that government departments could intervene to support the firm. However, there were indications that functional networks within government and resource networks between government and firm might be too fragile to support the firm to enable it to weather the 'tough' times.

The analysis identified a range of critical points of misalignment which could inform strategic policy prioritization and future interventions – in terms of bridging funds, IPR frameworks, accessing global markets, interactive capability within universities and government departments, to highlight but a few. It highlighted a more fundamental issue that could undermine any future strategic policy interventions.

The depth and extent of network alignment within and between the subsystems of the national technological system and the industrial subsectors in South Africa are not yet able to support knowledge intensification adequately.

Indeed, the weak capacity of key government agents and the lack of will to provide decisive leadership in policy implementation have been identified as a binding constraint on growth and development in general in South Africa. Stronger, wider and deeper complementarities and overarching linkages within firms, within government and universities, and between government agencies, universities and firms, could support the achievement of shared developmental goals more effectively. Without these conditions, it may not be possible to sustain competitive spin-off firms from university-based research – or other forms of interaction.

The challenge for HESA is to identify ways to promote such complementarities and linkages between government agencies, universities and firms. The following section goes on to consider some of the possible areas of intervention.

2.2 THE POLICY ENVIRONMENT TO PROMOTE INTERACTION

It is evident that a critical problem lies not necessarily in the policy frameworks to promote science and technology, but in the alignment and coordination between sub-systems of the national system of innovation, and within subsystems, between key agencies and actors.

2.2.1 A DISJUNCTURE BETWEEN HIGHER EDUCATION, SCIENCE AND TECHNOLOGY AND INDUSTRIAL POLICY

A major problem has been the lack of coordination between the departments responsible for higher education, for science and technology and for industrial policy and economic development. The DST and Department of Trade and Industry (DTI) fund a number of targeted programmes, and DST plays a co-ordinating role for many of the public programmes to promote university-industry interactions, high level human resources for science and technology, research and innovation (DST, 2010). Many of the key informants interviewed were of the opinion that overall, the DST is more focused on driving university-industry interaction than the department of higher education and training. The former national education department tended to focus on issues of access, student throughput and equity, rather than promoting research and innovation in higher education.

There was a strong trend on the part of some higher education agencies and institutions to oppose university-firm linkages and a perceived instrumental emphasis on universities as producers of high-level skills for the economy (RESDI Kruss 2010). The Council on Higher Education has not actively promoted university-firm interaction, although it has promoted community engagement actively. The HEQC has not included innovation or firm interaction in the generic criteria for institutional audits, but it has included community engagement.

Only the research-related criteria for research intensive universities included the requirement of structures to manage and monitor the commercialisation of research, but these did not apply to universities of technology which have emergent activity in this regard, appropriate to their institutional missions. A body like SARIMA has led and coordinated the professionalization of research management and innovation.

The concern of the new Department of Higher Education and Training is with skills development, and the creation of a vibrant post-schooling system with articulation between FET colleges, universities and firm training (Ministry of Higher Education and Training 2011). This may promote closer interaction between universities and firms in relation to strengthening and revitalizing traditional forms of interaction – those related to sponsorship of programmes, the production of graduates with the 'right kind' of skills and attitudes, collaboration around curriculum development for professions, and customized training.

Industry interaction is not on the DHET or CHE's future agenda of priorities. However, the focus of the HEQC second cycle of institutional audits is on the quality of teaching and learning, pedagogy and curriculum. This emphasis provides an opportunity for more structured and systematic interaction with firms and industry associations in specific sectors and professional bodies in relation to the emphasis of teaching programmes – bearing in mind the trend highlighted in Section One, that most academics claim to interact with firms in the form of preparing graduates with appropriate skills and other teaching related traditional forms of interaction.

Industry leaders interviewed report concerns about the loss of capabilities in higher education, especially in relation to reproducing the technical and technological skills required in future. A successful instance of such traditional forms of interaction is Eskom's longstanding Tertiary Education Support Programme, which since the 1990s has collaborated with many university departments, providing funding in relation to bursaries, skills development and research (with the research agenda decided by the university itself). Research funding may also be supplemented by service forms of interaction, contract research specific to Eskom requirements. The programme builds capacity in the university and in Eskom, on the engineering and technical side but increasingly also in relation to management and leadership. The research collaboration has the advantage that it may expose the universities to the technological capabilities of Eskom's other national and global partner networks in firms, science councils or other universities.

In parallel with and separate from these educational priorities, the DST and DTI continue to promote research and innovation, emphasising a central role for universities in the national system of innovation in their funding mechanisms.

For instance, the National Research Foundation (NRF) has increased its emphasis on university-industry interactions over the past ten years as part of the promotion and support of research funding and human resource development, and there is a commitment to continue promoting interaction in future through the THRIP programme. There has been a conscious effort every year to promote THRIP at universities with poor participation and correct the imbalances of funding allocations. Another DTI mechanism that may impact on university-industry interaction is the Support Programme for Industrial Innovation (SPII), managed by the Industrial Development Corporation. SPII and THRIP follow the priority sectors of the DTI, but no sector is excluded from the programmes. The SPII is designed to assist the development of innovative products and processes, taking them from the proof of concept stage to the pre-production prototype (SPII 2011). Participating firms are not required to interact with universities, but it is encouraged. Past SPII projects have often involved universities of technology to assist in development or transfer technologies for SMMEs. If skills are lacking, the agency recommends institutions with the relevant skills such as universities of technology with specific sector strengths. SPII plays an intermediary role, fostering relationships.

A common challenge for these programmes has been to involve more SMMEs in line with government priorities. As the firm data in Section One, showed, very few small firms interact with universities, and if they do it is generally in the nature of service forms of interaction, consultancy or occasional research. Key informants interviewed stressed that policy incentives for smaller businesses could be improved. The process of applying for the R&D tax incentive for example, currently is very difficult for a small business, and does not specifically encourage small businesses to do research with universities. A few years ago SPII took drastic steps to increase participation by limiting some programmes to SMMEs. These restrictions have been lifted now that greater participation by SMMEs has been achieved. In the THRIP programme there are incentives to encourage large industries to interact with SMMEs.

The National Advisory Council on Innovation NACI has attempted to foster a stronger link between industry, higher education institutions and science councils, and has advised the minister on ways to strengthen the relationship between the departments of science and technology and higher education. For instance, a joint task force with the CHE attempted to find ways to incentivize more (black) students to pursue post-graduate education. This included interaction with industry around funding for NSFAS and support to FET Colleges. As an advisory body, NACI has a relatively limited reach in terms of intervention, but it is a potential intermediary partner for HESA in this regard.

The general absence of coordination and aligment across departmental boundaries is likely to impact on the promotion of interaction significantly.

2.2.2 POLICY SHIFTS

A number of policy changes in response to an OECD (2007) review of the national system of innovation are currently being implemented. These are viewed with some trepidation as to their potential impact on improving coordination and alignment in the national system of innovation.

Although the broad mandate of each programme has not changed, SPII and THRIP have been refined and adapted over time to accommodate evolving technologies. Shifts in government priorities do impact on what is emphasised. Job creation is now very high on the list of priorities used to award funding. As noted in Section One, despite its successes funding for THRIP has been lowered to R155 million in the past financial year, trimmed down from almost R200 million in past years. The SPII fund is R74 million, and available funds have also diminished over the last few years. R&D funding targets have to compete with other government programmes and priorities that impact on what is possible. The impact of R&D expenditure can only be assessed after a number of years whereas the impact of spending on houses or infrastructure can often be seen in a much shorter time frame. Numerous policy changes, a push to increase SMME participation, and greater BEE emphasis may also be contributing to lower THRIP participation over the last three to four years. A shrinking funding base for research interaction is thus a challenge that is likely to impact.

A new high level national coordinating agency, the Technology Innovation Agency (TIA), is in the process of being formed, and has implications for entrepreneurial and network, and possibly even service, forms of interaction. Coordination and cooperation between the NRF and TIA is viewed to be important and is emphasised in official documents, but is as yet embryonic. The TIA incorporated a number of DST's innovation instruments[3] including the Innovation Fund (DST, 2010), which operated from 1999 until 2010 and funded many university researchers to develop cutting edge intellectual property (IP). However, in most cases, this IP never reached the stage of commercialisation. The TIA believes that failure to commercialise was due to a lack of market understanding, even when universities were given guidance. There are examples of a few funded researchers who had an industry partner working in a consortium, which were much more likely to commercialise their product. As a result, the TIA has stipulated that in future, universities seeking funding for technology development must find an industry partner and raise 20% of the funding themselves. This forces universities to speak to the private sector and find industry players who can potentially use the technology. This can be difficult for the universities, but the TIA believes that this is a model that will work to move applied research into the market. If industry can see the value of an investment then it sends a strong signal about the IP, indicating a market need, market relevance and a lower level of risk to the TIA and other funders.

The TIA has a range of five products, suited to individuals, universities, large industries and SMMEs, suited to projects that are expected to reach the market within 5 years. Early stage research is not funded as it is deemed too high risk. The TIA will typically take companies forward to the stage where they are generating revenue and then invite venture capitalists to take over funding. The TIA's existing portfolio is heavily weighted towards universities and science councils, as much as 70% of current funding. Ideally TIA would like to do more industry funding and equity matching funding in future. One of the five products is specifically aimed at building university-industry interaction. This is viewed as critical by the TIA, since South African firms are often stagnant when it comes to technology upgrading and innovation (as shown in Section 1), which may be because they do not have the required absorptive capacity. Firms often cannot afford staff with the R&D or innovation skills and capabilities, which is when the TIA can play a role, bringing in universities to work on a project for the benefit of the firm.

The TIA will thus potentially be an important driver of entrepreneurial forms of university-firm interaction in future, and a partner for HESA in this regard.

Linked closely with this thrust is the new Intellectual Property Rights (IPR) Act, which defines the rights of the state in relation to intellectual property derived from publicly financed research (DST 2011). The National Intellectual Property Management Office (NIPMO) has been established to play a monitoring and evaluation type of role. Views on the implications of the new IPR Act are mixed, and it is too early to see the full implications. One of the main rationales was to ensure that there is sufficient public benefit from intellectual property generated or supported through public funds, and that IP does not remain locked into the university without an 'owner'. The implication for universities is that they need to develop the capability to evaluate their IP and assess if it can be commercially exploited. It is also mandatory under the new act that universities must establish intellectual property management offices. Many universities already have intellectual property management offices, or technology transfer offices (TTOs). TTOs not only manage the IP of the university, they employ individuals who understand markets and offer academics advice on commercialisation of IP with strong commercial potential.

Some key informants saw the new IPR act as a positive intervention, in the very early stages of implementation. Others claimed that there is nervousness in industry over the IPR act. After interacting with universities, firms would prefer to be left to their own devices to maximise benefits for industrial partners. Industry is generally perceived to be better suited to exploit IP than universities. A firm can find an exploitation partner to commercialise IP and pay royalties, if it does not exploit the IP itself. One informant claimed that this may be a contributing factor to the reduced participation in THRIP. The new IPR act adds to the multitude of priorities THRIP is trying to achieve, increases the complexity of rules and creates uncertainty for firms.

3 The Advanced Manufacturing Technology Strategy (AMTS), the biotechnology innovation centres (BioPad, LifeLab, Cape Biotech, PlantBio), the Innovation Fund, and the Tshumisano Trust (DST, 2010)

Some argued that the new act will complicate IP ownership, which may be a disincentive to collaborate on research and put industry research funding at risk.

A more positive opportunity lies at the regional level. Over the past few years, DST has developed a strategy to promote regional innovation systems, and universities are expected to play a key role at this level, to understand regional dynamics and sectoral priorities (DST 2009). An emerging success story is the Cape Higher Education Consortium which is coordinating activities between four local universities, provincial and metropolitan local government, and local firms to promote socio-economic development (CHEC 2010). Other examples are found in Limpopo province (Lorentzen et al 2009) and the Eastern Cape, through the work of ECCSEC. Such organizational forms provide important mechanisms for developing substantive and potentially sustainable relationships between universities and key social and economic actors in their immediate local contexts.

2.3 HESA'S ROLE IN COORDINATION AND ALIGNMENT

Promotion of university-firm interaction needs to be based on a thorough understanding of these conditions, and how they can facilitate or constrain specific forms of interaction.

DTI, DST and NRF mechanisms promote service forms (contracts) or network forms of interaction, but significantly, the new TIA mechanisms and the structures established by the IP Act tend to promote primarily entrepreneurial forms of interaction. The CHE and DHET, and NACI and NRF as key intermediary agencies, are likely to promote traditional forms of interaction. Regional and local partners can promote all forms of interaction, and are particularly well placed for network forms of interaction that require proximity and the exchange of tacit knowledge. HESA will need to build coordinating relationships with all of these agencies, in order to promote the full spectrum of forms of interaction. The next section goes on to explain why a balance of different forms of interaction is significant.

SECTION **THREE:**

BALANCING FORMS OF INTERACTION AT THE INSTITUTIONAL LEVEL

In a review of the multiple roles universities are expected to play in knowledge society discourses, Valimaa and Hoffman (2008: 277) identify a tendency to 'describe higher education from the outside, looking in'. Most often, national policy frameworks provide normative expectations of how a higher education system should develop, but few operational arguments as to how to achieve these multiple goals, nor an understanding of the limitations of universities and of the challenges posed to their present structures. Universities are under pressure to transform internally to meet the external challenges of social accountability and to contribute to socio-economic development.

This section moves to focus on the promotion of interaction at the institutional level, the level that is within the power of leaders, managers and academics to shape and influence more directly.

The South Africa higher education policy framework has encouraged universities to define a differentiated mission based on their institutional type, their historical strengths and their strategic niche areas. At the institutional level, it is significant for institutions to develop a balance of forms of interaction with industry and other external social partners that is appropriate to their strategic direction and capabilities (Kruss 2005a, 2006b).To do so, institutions need an analytical framework to be able to identify what the appropriate balance can be in specific knowledge fields, and across the institution as a whole. They also need to know what are the policies, structures and mechanisms they can use to promote interaction with firms.

Section 3.1 argues that it is fruitful to use the matrix in Figure 1, to identify the forms of interaction in an institution, and to consider who benefits from the different forms of interaction and how. Which channels of university-firm interaction are more likely to benefit and less likely to risk learning and capability building in individual universities, and in the national system of innovation?

Section 3.2 shifts the focus to highlight the need for building stronger interactive capabilities within universities themselves, by showing how universities organise internally to promote and manage firm interaction.

Section 3.3 briefly considers the potential for and significance of, alignment between institutional policies to promote firm interaction, and community engagement.

3.1 ANALYSING CHANNELS AND BENEFITS

Different forms and channels of interaction are strongly associated with specific benefits and risks for innovation. Arza (2010) has analysed the voluminous literature to identify a matrix of possible associations. Benefits for universities are either intellectual or economic, while benefits for firms may be short term (related to improved production) or long term (related to innovation). These are all primarily private benefits, whether for firms, universities or individual academics. Arza (2010) adds a further dimension particularly pertinent in developing countries - different channels also may be associated with significant social risks for knowledge production and diffusion in the national system of innovation over the long term (Nelson 2004). Four main sets of risks are identified: weakening the quality of university teaching and research by capturing research agendas; high opportunity costs of industry interaction; privatization of research outputs; or a lack of social accountability in setting research agendas.

The policy implication is that the channels that are more to the benefit of universities and firms should be promoted, and conversely, those with highest risks should be avoided or minimised, so that more effective interaction can contribute to build university and firm capabilities and the national system of innovation in developing countries.

Arza (2010) argues that the bi-directional channels – what we have called network forms of interaction – are of greater mutual and long term benefit and should be promoted more widely. We argue instead that an appropriate balance of different forms of interaction should be promoted, suited to the strategic purpose of the research group or university, and to the broader goal of building a national system of innovation.

Table 19 provides an illustration of how such a matrix can be used, by analyzing case studies of the firm interactions of six biotechnology research groups at two universities.

The matrix can be used to analyse the existing forms of interaction in a department, or a faculty or a specific knowledge field, or in an institution as a whole at an aggregative level. A map of the relative scale of each form can then be plotted. This provides the basis for discussing the implications of the particular pattern. What are the main benefits and risks faced in that unit or field, what are the best mechanisms for dealing with those risks, and what are the trade-offs for promoting one or more forms of interaction more or less actively? Such decisions can only be taken if they are informed by the unit's strategic mission and goals, in the context of national policy frameworks.

So for instance, the lung disease group aims to develop health solutions for the poor and marginalized in relation to asthma, TB and so on.

It has a number of traditional channels of interaction with firms in the form of sponsorship of buildings and research facilities. It has a number of service channels of interaction in the form of drug trials it conducts on a contract research basis. It then uses the income from the service channels of interaction to fund strategic research through bi-directional channels – or network forms of interaction - with local health authorities, local government, communities and the private sector, to develop community health interventions.

To take another example, at an institutional level. If an institution aspires to develop its research culture, but has not put in place mechanisms to control the growth of service forms of interaction that have high opportunity costs for academics and departments, such as consultancies that only benefit the individual academic financially (as was the case with some of the projects of the bioinformatics research group), this may militate against the development of more beneficial bi-directional network forms of interaction that could contribute more effectively to the achievement of institutional or departmental goals.

The case studies illustrate that academics and universities need to develop their abilities to plan interaction more strategically.

TABLE 19. CHANNELS, BENEFITS AND RISKS OF FIRM INTERACTION IN THE HEALTH BIOTECHNOLOGY SECTOR IN TWO SOUTH AFRICAN UNIVERSITIES

	Channels	Benefits		Risks for NSI
		University	Firm	
Bioinformatics group	Service Commercial	Economic (individual academic)	Short-term production	Opportunity costs high risk. Lack of accountability high risk. Weak quality high risk
Lung disease group	Service Bi-directional	Economic Intellectual	Short term Long term innovation	Opportunity costs low risk. Privatization of public research low risk. Lack of accountability low risk
HIV/AIDS vaccine group	Service (the research group as customer) Traditional (donors)	Intellectual	Long term innovation (to public health benefit)	Opportunity costs low risk. Privatization of public research low risk. Lack of accountability low risk
Cardiac tissue engineering group	Bi- directional Commercial	Intellectual Economic	Long term innovation	Privatization of public research high risk (interests of foreign firms)
Hypertension drug development group	Commercial Bi-directional (university spin-off)	Economic Intellectual	Long term innovation	Privatization of public research high risk (interests of foreign firms). Opportunity cost high risk
Cancer diagnostics group	Commercial Bi-directional (university spin-off)	Economic Intellectual	Long term innovation	Privatization of public research high risk (interests of foreign firms). Opportunity cost high risk

Source: Kruss 2011

3.2 HOW DO INSTITUTIONS BUILD INTERACTIVE CAPABILITIES?

How do universities in specific contexts develop new capabilities to interact with firms and other external partners? A university may have excellent academic reputation and research or teaching capacity, but there is no one-to-one relationship between this capacity and successful outcomes. Leveraging competencies into interactive capabilities depends on abilities and circumstances (von Tunzelmann 2007). A research unit in a university may have competencies in the form of academics with PhDs that represent a potential critical mass of research expertise that could be a basis for interaction. However, they may find themselves in imposed circumstances that do not allow them to benefit from this expertise. Some of these circumstances may be external to the university, in relation to firm demand or the policy environment. Of particular concern in this section are the imposed circumstances that are internal to the university – and subject to institutional change efforts. It may be for instance, that prevailing academic incentive systems do not value and reward applied research conducted for firms, or it may be that significant academic groupings resist new strategies promoted by university leaderships, or it may be that academics lack understanding of external needs and mechanisms of effective interaction with firms, or the way in which the university is organized internally may militate against effective interaction with firms. There is a vast research literature on university-firm linkages in developed countries on which many South African universities have drawn, on the internal organizational and external interface mechanisms that enhance interaction, such as funding, incentive schemes, technology transfer offices, incubators or contracts offices (see Klitkou et al 2007 for an overview).

Drawing on a study by Martin (2000) of the institutional practices typically established to manage university-industry relations in twelve developing countries, a distinction was drawn between internal and external interface structures to build interactive capabilities.

Internal interface structures refers to those dedicated forms of organizational development created within an institution to support relations with industry, such as specialized internal structures for technology transfer, dedicated managerial posts, offices for continuing education or technology innovation centres. External interface structures play a similar role but they typically have a separate legal status from the institution, to enhance flexibility and responsiveness, and to create a professional, higher-status, market-related interface, such as university-owned companies, incubators, science parks and consultancy centres. The promotion of different forms of interaction requires different interface structures and mechanisms. Commercial forms require incubators and IPR offices, but services forms such as consultancy require internal policies to regulate time and academic workloads, while skills development requires mechanisms for consultation between academics and sectoral organizations. Internal and external interface mechanisms will need to be aligned with the pattern of forms of interaction promoted at each institution.

There are considerable differences between institutions in the balance between teaching and research, in science and technology research capacity and productivity, and in the cultures and forms of research management that have evolved – all of which shape their response. This section provides a schematic overview of the main types of institutional response found in South African universities (Kruss 2005a, 2005b). Two key distinctions were drawn, first, the extent to which institutions had either a strong or an emergent research capacity, particularly in science, engineering and technology fields. The second key distinction was the extent to which institutions had a highly structured, regulated and proactive organizational response in an attempt to promote interaction with industry, or whether they had a largely unregulated laissez faire organizational response. These two dimensions were assigned to two axes, to create an empirically based classification of four contextualised ideal types of institutional response (Figure 2).

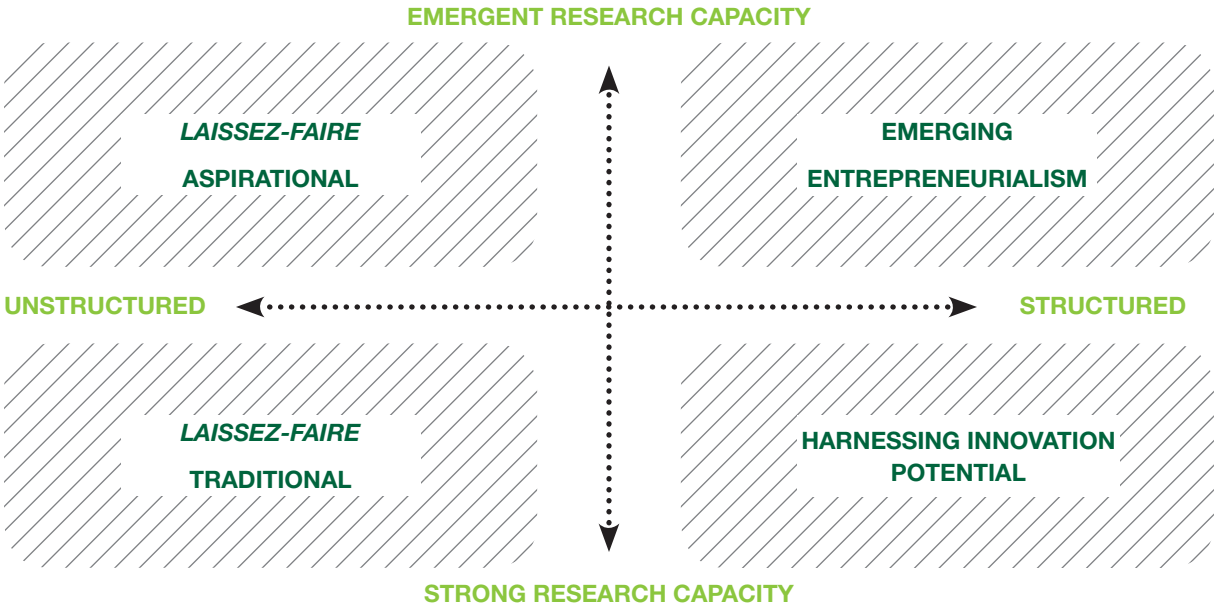

FIGURE 2. INSTITUTIONAL APPROACHES TO INTERACTION

To start in the bottom right corner. Harnessing innovation potential is in many respects an ideal approach. Sound research capacity and structured institutional response mean that they are able to build and support interactive capabilities of academics. These institutions are well resourced, with long-standing links with business and industry, some with research roots and expertise strongly shaped by military R&D in the apartheid period. Research excellence is prioritized, and hence an attempt to create a balance in favour of fundamental research, while strategically exploiting the opportunities for applied and strategic research. These universities have well-articulated and well-integrated formal institutional strategic and research policies, accompanied by long-established structures and mechanisms to co-ordinate and support research activity in general, at both central and faculty level. Formal strategic policy explicitly supports innovation, encompassing a conception of interaction framed in terms of developing a 'strategic balance'. Policies encompass the aspiration to relate to industry in academically beneficial terms and are not explicitly driven solely by financial concerns. Intellectual-property-rights policy typically reflects a concern that potential tensions be resolved, that interaction should be structured and designed to generate research from which the academic can derive a publications record but which does not compromise the commercial interests of the industry partner.

Strong centralized steering and supportive structures created by management to promote industry interaction. A number of high-level internal interface structures are established by central research management, such as dedicated structures to manage and process all external contracts, and to provide expertise to support the process of patent applications, royalties and protecting intellectual property. They created external interface structures to facilitate and manage the relationship with industry, such as university-owned companies, and involvement in incubators established in response to national incentivization schemes in specific technology fields.

An emerging entrepreneurialism approach is more explicitly driven by financial imperatives, and at the same time, to consolidate and develop scientific research capacity. Interaction was underpinned by a coherent institutional attempt to develop research expertise in potentially lucrative directions, and to generate 'third-stream income'. They articulated a discourse of an entrepreneurial university or university of technology. Priority tends to be given to research in application, addressing problems experienced by the public sector, the private sector and the community. These institutions had limited research expertise and capacity in science and technology, and hence a more limited base for industry partnership. Most had relatively new formal institutional research policy and development plans, typically aimed to develop and improve research capacity.

They, too, had a highly regulated, structured, proactive institutional response, led strongly from the centre by institutional leadership, and largely based in dedicated structures outside of the mainstream structures of institutional power. In their strategies and structures these institutions adopted 'textbook' features drawn from international 'best practice', particularly investment in external interface structures. Through the establishment of technology stations, science and technology parks, technology incubators that focus on SMMEs, or 'design solutions' centres such as prototype product development, they revealed ambitious plans, but the scale of operations was generally modest. In some cases, they were driven by an enterprising academic or research unit, separate from official initiatives, but subsequently formalized.

A Laissez-faire aspirational approach tended to enshrine a view of partnership as an 'essential necessity' that can contribute to the funding base of the institution's research, and to its commitment to responsiveness and community relevance. They too are focused on developing research capacity, with a small emergent research base in niche areas. However, they have a largely unregulated and unstructured approach. These institutions do not have clearly formulated and well-structured institutional policies, structures or mechanisms to support interaction. They tended to have policy documents that were largely symbolic and aspirational, providing frameworks for future institutional development. Similarly, these institutions tended to have internal interface structures that support and facilitate research, rather than promoting interaction. There were few formally structured entities and these were less inserted into institutional structures of power. Thus they may leave much of the initiative to individual academic 'champions' on an ad hoc basis, or facilitation in terms of the tacit knowledge and expertise lodged in an individual manager at central level.

A laissez-faire traditional approach is similar, but an ambivalent to negative attitude prevails in institutions that have strong, well-established research capacity. While individual academics may interact with firms, institutional policy and leadership tend to tolerate interaction as a 'necessary evil' that has to be controlled or they are opposed to partnership as 'inimical to traditional academic practice'. These universities implemented policies and practices related to intellectual policy and third-stream income in a rather ad hoc and inconsistent way, in an attempt to control the potential 'excesses' and protect the traditional academic project, in the face of high levels of academic contestation. They did not to have a centralized formal research policy or strategy, nor did they have a coherent policy or strategy relating to interaction. Central institutional leadership was not proactive, and there was little central steering. Initiatives of individual researchers provide a more organically rooted base of experience, from the bottom up. The laissez-faire institutional approach was seen as a significant constraint by those researchers who desired to or did pursue interaction with industry.

The matrix in Figure 3 helps to understand why some universities develop interactive capability more effectively, by understanding the policies, structures and mechanisms associated with each response. It can help an institution to develop its own mechanisms to operationalise and support its strategic direction and plan for interaction.

3.3 INSTITUTIONAL COORDINATION AND ALIGNMENT

A final significant issue relates to institutional policy to promote interaction.

Over the past three or four years, a shift towards institutionalization of a broader concept of community engagement or social responsiveness as integral to academic scholarship is emerging (CHE 2010, University of Witwatersrand 2009, Muller 2010). The HEQC institutional audit process was a direct driver of more systematic integration of 'community engagement' within institutional missions, structures and incentive schemes, in relation to teaching, research and outreach or service. This provides an opportunity for universities to reconceptualise interaction in terms of socio-economic development goals in an integrated manner.

Typically, there are separate structures and mechanisms within a university to promote research, innovation and 'community engagement'. The challenge – as at the national level – is to bridge a potential disjuncture that sees these structures operating on their own separate tracks, and to promote internal coordination and alignment.

At some institutions, a new concept of social responsiveness or engagement is being articulated, so that a wide range of partners of interaction - including firms, communities and government – and a wide range of forms of interaction - in relation to teaching, research and outreach - are recognized.

The conditions are favourable for a cross-fertilisation of ideas from those within universities who have gained valuable experience of what is required to interact with firms in a beneficial way, and those who have experience in addressing a range of national socio-economic priorities, whether health or poverty or the environment. How may technology transfer offices adapt their expertise to include local government or community partners, or intellectual property and commercialization experts extend their reach to create not-for-profit community-based spinoff companies? Precedents exist for what is possible, where academics are involved in multi-disciplinary teams to address complex social problems through research and innovation, in ways that inform teaching and learning and the academic project. Examples are new software generated to adapt cell-phones for health interventions in impoverished communities, or genetic research on plants or seeds in networks with small growers, local communities and large firms.

Such reconceptualisation is important as a basis for stronger internal alignment and coordination within institutions.

SECTION **FOUR:**

TOWARDS A STRATEGY FOR HESA

The purpose of the study was to lay the foundation for a common framework and a functional model for HESA and its members to anchor, promote and sustain university-industry partnerships.

The research has revealed complexity, and the multi-layered nature of the task. A simple, uniform framework and model applicable to all HESA members is not possible. What is possible is to develop a framework and a set of analytical tools to promote university-firm interaction in a more integrated, contextually appropriate, differentiated and specific manner than has been the case to date.

The core of such a framework rests on the assumption that what is required is to build interactive capabilities. An institution may have strong academic capacity but find itself in imposed circumstances that constrain interaction with firms. Imposed circumstances may be external to the university in relation to firm demand or the policy environment, or internal to the university in relation to institutional policies, structures and interface mechanisms. Of course, in the South African context, some institutions may lack academic capacity and be required to build it at the same time as developing interactive capabilities.

HESA can intervene in relation to external circumstances, but their efforts should be focused primarily on the imposed circumstances that are internal to the university and hence, subject to its members' own institutional change efforts.

Key principles for a framework drawn from the analysis are:

1. The conceptualization of university-firm interaction within a broader framework of university responsiveness and interaction, that includes teaching, research and outreach activities, and that includes a range of external social partners
2. An appreciation and promotion of differentiated university approaches shaped by institutional types, knowledge niches and expertise, institutional historical trajectories and cultures
3. The promotion of a strategic balance of diverse forms of interaction with their attendant benefits and risks, that address university and firm priorities and contribute to build the national system of innovation
4. The development of interactive capabilities on the part of academics, heads of departments, institutional managers and leaders
5. An understanding of firm demand and the specificities of innovation and R&D dynamics in priority sectors and relevant knowledge fields
6. The promotion of coordination and alignment between universities and other agencies in the national system of innovation, and of alignment with national socio-economic development priorities
7. The promotion of stronger collaboration within the national science and technology system across institutional boundaries of universities and science councils, as a basis for more sustainable interaction

Based on the these principles, it is possible to identify roles for HESA as a national coordinating and advocacy agency working at three levels: in relation to internal imposed circumstances with member institutions, and in relation to external imposed circumstances with firm and sectoral agencies, and with government and other agencies in the NSI.

HESA'S ROLE IN RELATION TO ITS MEMBER INSTITUTIONS: BUILDING INSTITUTIONAL INTERACTIVE CAPABILITIES

At the broadest level of advocacy, there is space for HESA to promote wider debate on responsiveness and interaction in relation to changes in academic roles and identities, and to national priorities. Such debate is important amongst all academics – going beyond the typical focus on research and innovation managers or leaders. Articulation and coherence of institutional policy is essential, but greater consensus and permeation of new approaches through all levels of an institution is required, to change academic practice in a sustainable manner.

More tangibly, HESA can support strategic planning for industry interaction at an institutional level.

It can promote the use of analytical matrices to enable institutions to identify a desirable balance of different forms of interaction, set goals and devise strategic plans, in the light of existing academic capacity. The conceptual matrix provided in Figure 1 is a useful tool in this regard.

HESA can then support sharing of best practice in relation to the internal and external interface mechanisms required to incentivize beneficial forms of interaction and minimize the risks of channels with potentially negative effects. Understanding the current institutional approach using the matrix in Figure 2 can be useful to identify strengths and weaknesses. The 'harnessing innovation potential' approach serves as an ideal, in which there is clear policy, strong centralized steering, well defined internal and external interface mechanisms and space for the initiative of individual 'academic entrepreneurs'.

There is much good practice that can be shared, as are there plenty of 'worst' practice cases where reflection on institutional failures can prevent costly mistakes being repeated elsewhere. Examples of issues identified as problems are provided for illustrative purposes in Box 1. HESA can develop creative ways to facilitate such sharing, including websites and online discussion spaces, collaboration with organizations like SARIMA, SAHECEF, regional workshops and the like.

BOX 1. INCENTIVISING BENEFICIAL EFFECTS AND MINIMIZING RISK – PROBLEMATISING BEST PRACTICE INTERFACE MECHANISMS

Commercialisation forms of interaction	Services forms of interaction
• How can limited expertise to manage IPR be shared in regional technology transfer offices • What are the best approaches to the ownership and management of spin off firms • How can venture capital be sourced nationally so that spin-off firms are not vulnerable to global markets • How can funding be accessed to move from basic research to proof of concept • What are the best vehicles to move from proof of concept to proof of product and what partners are required	• What are the interface mechanisms required to offer customized training to firms • How can contracts offices manage the negative effects of contract research on publications and students • How can heads of department manage and monitor workloads to allow for consultancies without risking core responsibilities
Traditional forms of interaction	**Network forms of interaction**
• How can institutions attract firm sponsorship and donations, particularly those in rural areas • How can institutions build collaborative relationships with industrial bodies, professional associations, SETAs and FET colleges to inform programme and curriculum design in areas of scarce or critical skills • What are the interface mechanisms to involve firms more effectively in experiential learning and mentorship	• How can the dynamics of collaborative knowledge creation be managed • How can firms be involved in collaborative research networks focused on products with potential benefits for those in rural areas • How can research universities collaborate with comprehensive universities and universities of technology to benefit from their applied research and technology development expertise and build research capabilities

HESA'S ROLE IN RELATION TO FIRM DEMAND: PROMOTING SECTORAL INTERACTIVE CAPABILITIES

It will be critical for HESA to promote differentiated intervention at a sectoral level so that universities and academics develop a more informed understanding of firm demand for interaction, and the potential sectoral constraints on interaction.

It is of little value to hold meetings of high level 'business' and higher education role players to discuss what each can do for each other, or how each is failing the other. These remain largely at the level of symbolic interaction, and are far too general to be useful in promoting substantive interaction.

Instead, the empirical analysis has illustrated that what is needed are specific strategies to promote interaction in alignment with national or regional priority sectors. What is at the technological cutting edge in a specific sector, or what are the scarce skills needs in a sector or what are the missing intermediary agencies in a sector, and how are these aligned potentially with university capabilities? A targeted approach is likely to have better outcomes in the long term, by building interactive capabilities within a sector.

The aim is for HESA to intervene to develop sectorally specific strategies to promote interaction. Such intervention can begin with a pilot project focused on a well selected sector, and then, be rolled out progressively to other sectors.

The modalities are brokerage and information sharing with existing networks and programmes to consolidate resources and efforts, facilitation of collaboration at various levels, and commissioning and disseminating research.

HESA's role could include:

- Commissioning sectoral studies of skills, R&D and innovation demand as well as constraints in the NSI in relation to key sectors of higher education expertise.
- Extending and deepening higher education support for existing sectoral networks, such as the National Biotechnology Network, the Nanotechnology network or the Advanced Manufacturing Strategy Network.
- Facilitating closer alignment with DTI strategies, in particular, the Industrial Policy Action Plan, and with DHET strategies for skills development in specific sectors.
- Coordinating and deepening collaboration between universities of technology and research universities in relation to priority sectors for supporting SMMEs, such as clothing and textiles or automotives.
- Coordinating and facilitating collaboration with professional bodies such as SAICA or Engineering Council of SA in relation to high level skills.
- Facilitating regional support with science parks, incubators or centres of excellence.

HESA'S ROLE AT THE POLICY LEVEL: PROMOTING COORDINATION AND ALIGNMENT

At the national and regional policy level, HESA has an advocacy role to play as the voice of the 23 universities. The aim should be to promote better coordination and alignment of higher education priorities within the national system of innovation.

The modalities are to build relationships with key government departments and agencies that distinguish the relative responsibility and focus of HESA, as well as common priorities and areas of collaboration.

A key task is to develop more effective mechanisms for sharing information on university strengths and capacities to facilitate interactive capabilities more generally. Equally important, is to deepen government and agencies' understanding of what universities can do best, and how universities work internally, so that there are not unrealistic expectations of higher education.

Within the higher education sector itself, HESA has a role in promoting greater coordination and alignment of functional roles and responsibilities of different organizations at national and regional levels.

Figure 3 illustrates the potential HESA partners, distinguishing between government and other agency partners at three levels – national, regional and sectoral.

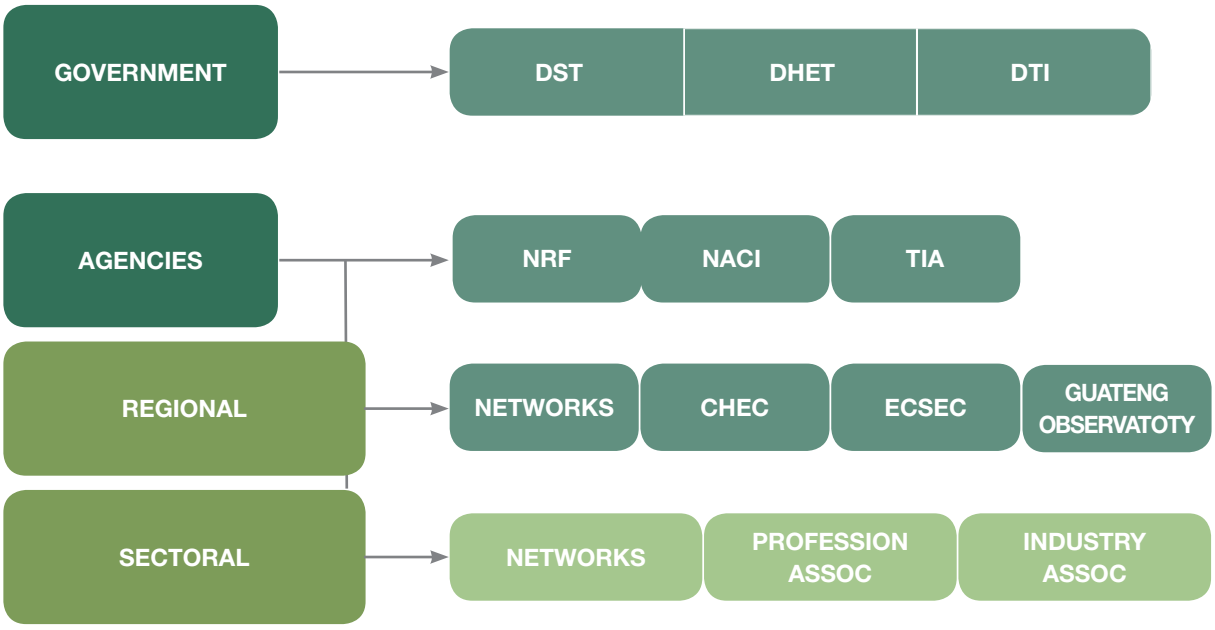

FIGURE 3. HESA COORDINATION AND ALIGNMENT PARTNERS IN THE NATIONAL SYSTEM OF INNOVATION

These partner agencies include:

- DST, DHET, DTI and DED in relation to coordinating government priorities.
- NRF in relation to funding and driving the agenda of research and innovation.
- TIA in relation to funding and driving the agenda of innovation and commercialization.
- NACI in relation to higher education's role in the NSI.
- CHE in relation to driving the agenda of teaching, research and outreach.
- SARIMA in relation to coordinating and deepening research and innovation management and hence, building interactive capabilities.
- SAHECEF in relation to coordinating and aligning university-industry linkages and university-community engagement.
- Regional higher education consortia and/or innovation forums in relation to coordinating efforts in regional innovation systems.

HESA may work with different sets of partners in relation to different forms of interaction. For instance, in relation to the promotion of traditional forms of interaction, it is more likely to engage with NRF and CHE, in relation to promoting entrepreneurial forms, with TIA and SARIMA and so on.

Finally, in conclusion, each of the three roles is mutually inter-dependent and reinforcing. Better alignment at the national policy level will support institutional interventions more effectively. Stronger understanding of sectoral dynamics will equip academics to interact with individual firms more effectively. And so on. In these ways, a virtuous cycle of interaction might result.

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APPENDIX 1: ACADEMICS WHO ENGAGE WITH LARGE FIRMS, SMMES AND MNES BY ALL CESM CODES AND THREE MAIN FIRM OUTPUTS

CESM code and Description	Spin-off companies			New or improved product			New or improved processes		
	MNE	SMMEs	Large SA	MNEs	SMME	Large SA	MNEs	SMME	Large SA
01 Agri&Renewable Resources	5	7	6	11	17	14	13	20	18
02 Arch. and Env. Design	8	9	9	13	13	12	22	28	27
03 Arts, Visual and Performing	8	9	9	13	17	15	16	22	21
04 Bus, Comm & Mgmt Sci	**40**	**53**	**47**	**52**	**67**	**63**	**84**	**106**	**109**
05 Communication	1	7	5	2	9	7	4	13	10
06 Computer Sc& Data Proc	**6**	**9**	**8**	**13**	**23**	**18**	**16**	**28**	**21**
07 Education	18	24	22	32	42	40	55	66	68
08 Engineering and Eng Tech	**45**	**50**	**50**	**72**	**88**	**88**	**100**	**118**	**122**
09 Health Care & Sciences	**28**	**39**	**34**	**57**	**65**	**70**	**76**	**93**	**101**
10 Home economics	1	1	2	7	11	9	6	10	8
11 Industrial Arts, Trades&Tech	1	3	3	6	6	6	8	13	12
12 Language, Linguistics& Lit	6	7	7	8	12	10	14	21	20
13 Law	4	5	3	9	12	9	12	18	13
14 Libraries &Museums	1	1	1	2	1	2	2	1	2
15 Life &Physical Sciences	**27**	**29**	**28**	**45**	**58**	**52**	**51**	**70**	**62**
16 Mathematical Sciences	4	6	5	7	9	11	8	12	14
18 Philosophy, Relig& Theology	0	3	2	4	5	5	3	6	5
19 PhysEd, Health Ed& Leisure	3	4	3	2	4	3	3	4	4
20 Psychology	2	4	5	3	5	6	5	7	10
21 Public Admin& Social Services	0	1		5	6	4	6	7	5
22 Social Sciences & Studies	2	6	4	7	11	13	16	19	19
Total	**210**	**277**	**253**	**370**	**481**	**457**	**520**	**682**	**671**

Source: HSRC 2010 database

APPENDIX 2. THRIP PROJECTS SUPPORTED AND OUTPUT (2008/09)

Institutions	Number of projects	Funds released			Students Supported	Research Publications	Patents
		THRIP (R)	Industry (R)	Total (R)			
Agricultural Research Council(ARC)	14	2,538,902	4,165,921	6,704,823	9	23	2
Council of Scientific and Industrial Research	10	3,932,998	7,313,700	11,246,698	65	9	0
Elsenburg Agricultural Research Centre	2	1,353,800	1,353,800	2,707,600	6	17	0
Mintek	1	3,245,675	6,491,350	9,737,025	6	0	0
Port Elizabeth Museum(Bayworld)	1	760,000	760,000	1,520,000	19	0	0
Subtotal SETIs	28	11,831,375	20,084,771	31,916,146	105	49	2
Cape Peninsula (University of Technology (CPUT)	3	552,800	795,900	1,348,700	10	20	0
Durban University of Technolgoy(DUT)	2	1,330,000	1,520,000	2,850,000	7	0	0
Tshwane University of Technology (TUT)	6	16,627,717	17,425,617	34,053,334	24	16	1
Vaal University of Technology (VUT)	1	332,500	665,000	997,500	2	3	0
Subtotal Universities of Technology	12	18,843,017	20,406,517	39,249,534	43	39	1
University of Cape Town(UCT)	31	14,614,838	30,967,900	45,582,738	236	226	3
North West University(NWU)	19	23,041, 401	26,435,486	49,476,887	255	59	1
Rhodes University (RU)	6	988,864	1,725,981	2,714,845	66	53	0
University of Fort Hare (UFH)	2	1,299,064	2,598,128	3,897,192	28	38	0
University of Kwazulu Natal(UKN)	16	10,072,886	20,241,298	30,314,184	84	50	0
University of Limpopo(UL)	1	100,000	200,000	300,000	1	6	0
University of Pretoria(UP)	40	15,965,131	34,288,032	50,253,163	276	191	0
University of Stellenbosch(US)	40	15,510,561	26,591,633	42,102,194	326	197	0
University of the Free State(UFS)	4	1,538,207	2,890,982	4,429,189	68	39	0
University of Western Cape(UWC)	5	6,044,660	12,289,001	18,333,661	87	42	4
University of Witwatersrand(WITS)	22	11,340,077	17,791,033	29,131,110	298	77	5
Subtotal Universities	186	100,515,689	176,019,474	276,535	1,725	978	13
University of Johannesburg (UJ)	4	461,386	1,343,118	1,804,504	34	30	0
Nelson Mandela Metropolitan University(NMMU)	9	6,878,808	8,831,514	15,710,322	58	44	3
University of Zululand(UZ)	1	400,000	800,000	1,200,000	6	11	0
Subtotal Comprehensive Universities	**14**	**7,740,194**	**10,974,632**	**18,714,826**	**98**	**85**	**3**
TOTAL	**240**	**138,930,275**	**227,485,394**	**366,415,669**	**1,971**	**1,151**	**19**

Source: THRIP annual report 2009

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