1

INTRODUCTION

This research report focuses on research partnerships between higher education and industry that have been incentivised by government-funded programmes. It represents Component 2 of a broader HSRC study, funded by the Carnegie Corporation of New York. The HSRC study explores research partnership and network relationships between higher education and industry in three high technology fields identified as critical for innovation in South Africa.

This Report presents empirical data gathered from a set of audits of two programmes, namely, the Technology and Human Resources for Industry Programme (THRIP) and the Innovation Fund (IF). These programmes, both currently housed at the National Research Foundation (NRF), were selected on the basis that they are at present the largest and most influential government-funded programmes in South Africa that aim to facilitate higher education-industry research linkages, as either a direct or an indirect component of their mission and practice.

1.1 The context

The study takes place against a contextual framework of higher education policy that promotes responsive higher education institutions and that recognises the significant role that higher education has to play in developing the knowledge and high-level skills that the country needs.

One of the key strategies identified to enable higher education to achieve these aims is captured in the notion of greater 'responsiveness'. The term 'responsiveness', used in the South African higher education policy context, implies that 'higher education should take seriously the problems and challenges presented by the societal context in which it operates' (National Commission on Higher Education 1996). The term refers to a 'shift of higher education to a more open and interactive system, responding to the social, cultural, political and economic needs of its environment and adapting itself to the changes in this environment'.

Kruss (2002) argues that the issue of responsiveness has taken the form of a 'symbolic policy', rather than a 'substantive policy'. She argues that the commitment to responsiveness, lying at the heart of higher education policy, has not been supported with substantive policy interventions that direct its form, how it should unfold, or what

mechanisms should be in place to promote it. Kruss argues further that the manner in which responsiveness is interpreted in practice is mediated differently across different institutions and by different sectors.

While this argument may currently have validity, international experience has highlighted the formation of higher education-industry partnerships as a key strategy for developing higher education responsiveness. Partnerships are, however, fuelled by a number of social forces that include, but are not limited to, the development of 'substantive policy' that promote and enable them. Gray and Walters (1998), for example, indicate that partnerships are driven by forces that include the shrinkage of higher education budgets; increased governmental support for industry partnerships; new demands from the global economy and changes in the way in which knowledge is produced. The authors argue that within this context, higher education-industry partnerships have grown in number, nature and stature.

One of the primary purposes of this study is to investigate the number and nature of higher education-industry partnerships, as incentivised through THRIP and the Innovation Fund. There is a significant body of literature that reviews how such collaborative endeavours operate to increase competitiveness, efficiency and social development in the context of the pressures of globalisation and the global economy.[1] Castells (1996), for example, argues that 'the ability of countries to compete in the international economy is directly related to their technological potential', a capacity that he sees as an attribute of the 'science-technology-society-system' that cannot be an attribute of individual firms. Improving national competitiveness, he argues, is increasingly dependent on the complex interaction between historically rooted political institutions and globalised economic agents. Within this context, Castells refers to increased 'networking' between organisations within the seemingly paradoxical paradigm of competition and collaboration. Organisations within different sectors are, he argues, beginning to see the benefits of working collaboratively, rather than in isolation in order that the efficiency, quality and quantity of outputs may be increased.

Gibbons et al (1994) focuses on what the authors refer to as a new mode of knowledge production, i.e., 'Mode 2' knowledge, where knowledge and information, traditionally produced in the academic realm, is increasingly linked to forms of application required in the economic and development sectors. 'Mode 2' knowledge is viewed by Gibbons et al as a 'transdisciplinary', rather than multidisciplinary form of knowledge. In this mode of knowledge production, the applied context becomes the primary locus, rather than the traditional realms of academic institutions, departments and disciplines. As such, research teams that bridge the traditional disciplinary and institutional boundaries are established around the locus of an economic or social problem.

Perlas (2002), on the other hand, has suggested the concept of 'threefolding' towards understanding the 'new social landscape'. He argues, through this concept of

[1] A comprehensive literature review has been undertaken in Component 1 of the project. See this for further details on the relevant literature.

'threefolding', that the forces, capacities and resources to change the world are clustered in the hands of business, government and global civil society – how institutions in these different sectors of society interact and respond to the 'new social landscape' will determine what kind of social life and society we have. According to Perlas, a healthy society is where the three realms mutually recognise and support each other and develop their initiatives with awareness of their potential impact on other realms.

It is in this light that the growing phenomenon of 'networks' between higher education and industry in three high technology bands – ICT, new materials development and biotechnology – is investigated.

1.2 Aim and focus of the study

The primary aim of the study is to explore the extent, forms and products of the research partnerships and linkages between industry and higher education institutions, as incentivised by government-funded projects, particularly in the three high technology fields – ICT, new materials development and biotechnology.

The study was envisaged as an audit of the research linkages and practices facilitated by the THRIP and Innovation Fund programmes. It aimed to describe the higher education and industry beneficiaries, to provide information about the motivation, initiation, operation, financing and termination of the partnership, and to provide information about the scale and nature of the products or outcomes of such partnerships.

An initial environmental scan revealed a THRIP database that allowed comprehensive investigation of these issues from the perspective of higher education beneficiaries, but a survey was required to obtain equivalent data for the Innovation Fund higher education beneficiaries.

It was determined that further information from the perspective of industry beneficiaries would provide a useful balance for understanding partnership and network practices. Accordingly, a survey of industry beneficiaries of THRIP and the Innovation Fund was conducted, which aimed to elicit conceptions of and motivations for partnerships, and the extent to which government-funded projects are believed to have aided and supported the development, management and success of research partnerships with higher education institutions.

The next chapter will describe the design and methodology of the study, of this set of surveys, data and documentary analyses from the perspective of industry and higher education beneficiaries, in greater detail.

The analysis on which this report is based thus draws on data from both THRIP and the Innovation Fund, at times separated to reflect their different nature and emphases, and at times combined to reflect their role as government-funded programmes. It also covers both the three high technology fields specifically as well as all research projects

funded by the two programmes, where appropriate. And it attempts to analyse the involvement and provide the perspective of both higher education and industry.

1.3 The structure of this report

Section A introduces and provides an overview of the THRIP and Innovation Fund programmes as two government-funded projects in South Africa (Chapter 3).

Section B provides an overview of the nature of higher education-industry partnerships from the perspective of industry beneficiaries, showing how respondents define partnerships and understand the nature of THRIP and Innovation Fund partnerships specifically, as well as a review of some of the indicators of collaboration (Chapter 4).

Section C, the heart of the report, analyses the data gathered on these government-incentivised research projects. Chapter 5 provides a brief overview of THRIP and Innovation Fund projects to lay the basis for the analysis that follows. Chapter 6 provides a breakdown of partnership budgets and expenditure. Chapter 7 goes on to describe the industry partners, while Chapter 8 focuses on the higher education institutions, and Chapter 9 focuses more specifically on the researchers involved, in THRIP and Innovation Fund projects.

Section D considers the contribution of government-funded projects. Chapter 10 begins a novel statistical analysis of the research networks and linkages involved in THRIP and Innovation Fund partnerships that is highly suggestive of the possibilities for future exploration. Chapter 11 reviews the contribution of government-funded projects by examining the form and scale of outputs in the three technological bands. Chapter 12 examines industry partners' perspectives on the contribution and sustainability of government-funded projects.

Section E provides a brief summary and conclusion, arguing that THRIP and Innovation Fund partnerships appear to have rested on a formula where mutual benefit is obtainable, and which represent exemplars of how partnerships can be used to develop science, technology and innovation in South Africa.

2

METHODOLOGY

This chapter will describe the design and the methodology of the audit in detail to provide a basis for reading the report.

2.1 Methodological aspects

The methodology for the study was designed to reflect the broader vision of value-adding partnerships encapsulated in the HSRC project. As such, an approach was adopted that aimed to include THRIP and the Innovation Fund as key stakeholders and partners in the study. In order to achieve this, a number of principles were adopted that underpinned the methodological tools and steps applied.

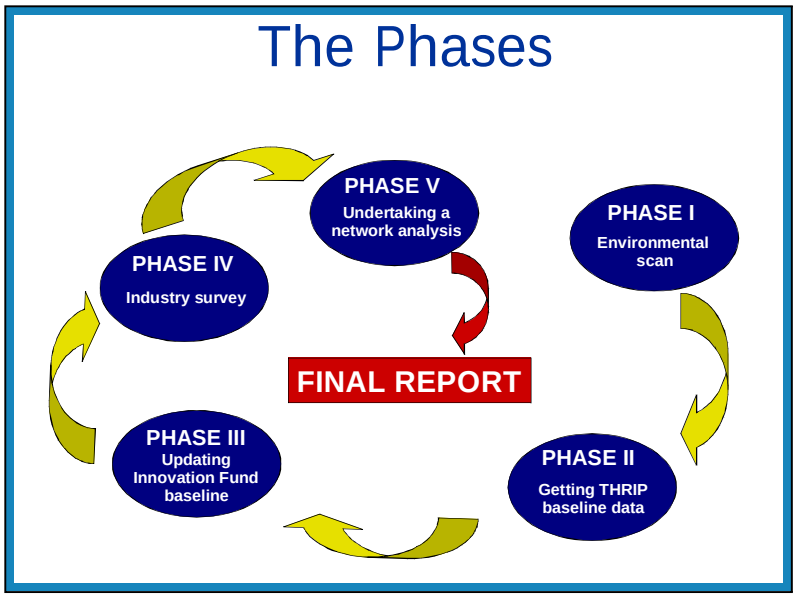
- The relationship between the HSRC, THRIP and the Innovation Fund should be developed as a long-term and sustainable relationship.
- The key stakeholders should buy into the project in a manner that enabled them to see the mutual benefit of the study to themselves and to the broader society. This encouraged close engagement and involvement in the project by THRIP. The Innovation Fund, having been moved to the National Research Foundation (NRF) only months before the study, was engaged in an intensive internal audit and re-orientation which meant that they were involved to a lesser degree. Both organisations attended a two-day workshop held at the HSRC, meetings between the HSRC research team and the programme leaders were held at the NRF and a workshop, hosted by the NRF, was held on 28 October in which preliminary findings were presented for discussion.
- Stakeholders should be provided with opportunities to input into the design, methodology of the project, as well as to engage with key findings as these emerged. Accordingly, a number of design and data complexities were discussed and resolved together with THRIP staff.

2.2 Key methodological steps

The key steps in the methodology for the audit are represented in Figure 1. Five sequential phases of data gathering and analysis included an environmental scan, the

acquisition of THRIP baseline data, updating Innovation Fund baseline data, an industry beneficiaries survey, and a statistical analysis of networks.

Figure 1: The research phases



2.2.1 Phase I – Environmental scan

An environmental scan was undertaken to review the activities of THRIP and the Innovation Fund, and to ascertain the availability of literature, reports and databases. The aim was to establish the extent to which partnerships exist in the three technological bands of ICT, biotechnology and new materials development. This exercise was performed by undertaking a scan of the documentary evidence and data available from the Innovation Fund and THRIP. In addition, in this phase a working relationship with THRIP and the Innovation Fund was developed. The environmental scan laid the basis for the approach and strategy for the subsequent phases.

A number of steps were undertaken during the environmental scan, including an Internet search, a Nexus search, an introductory interview, a documentary search, database analysis and a series of discussions with relevant players.

Internet search: An Internet search provided an excellent overview of both THRIP (www.nrf.ac.za/thrip) and the Innovation Fund (www.innovationfund.ac.za). It provided an overview of the projects, the names of relevant contact people and a sense of the missions, values and key goals of the programmes.

Introductory interview: In order to develop a solid understanding of the projects, an introductory meeting was scheduled with Dr Drennan, the Manager of THRIP, and Dr Lottering, the Director of the Innovation Fund. Attached as Appendix A is the interview schedule for these meetings, the aim of which was to:

- Introduce the project to the directors of THRIP and the Innovation Fund;

- Discuss ways in which the research project could add value to their own work;
- Discuss how they would like to engage with and work with the HSRC research team;
- Undertake a brief interview on the nature of THRIP and the Innovation Fund. The interview schedule for the introductory meeting was designed to elicit a broad understanding of the nature of the project, the data available at THRIP and the Innovation Fund that might be relevant to the study and the extent to which data and documents were available for an analysis by the three core focus areas of ICT, new materials development and biotechnology.

THRIP and the Innovation Fund were informed, during the introductory meeting, that the study would present data in an aggregated format rather than identifying the names of individuals.

Documentary search: A documentary search, undertaken at THRIP, highlighted a number of documents useful for the study. A list of all the documents is included in the Bibliography. Discussion with the Director of the Innovation Fund indicated that the Innovation Fund had limited documents available.

NEXUS search: A NEXUS search was undertaken to identify projects funded in the area of biotechnology, ICT and new materials development. The search provided lists of the research projects currently being undertaken in these three areas but did not indicate the extent to which any of these are currently being undertaken as higher education-industry partnerships. The search provided no information relevant to this study.

Other documentary search: A number of secondary sources were identified that could place this project within the broader research network in which it is located.

Database analysis: An analysis was undertaken of THRIP's database. THRIP's database, designed to support management decision-making, tracks a project proposal from application stage, to application review stage, to funding stage and to the stage of impact assessment. This database formed the basis of much of the analysis involving THRIP presented in this report. The researchers were informed that no database for Innovation Fund projects was available.

2.2.2 Phase II – Getting data from THRIP database

The specific data required from THRIP was determined after careful consideration of the general availability of data. THRIP staff provided invaluable support in identifying the data available and transferring the data from their server into the formats for analysis.

It should be noted there were a number of data issues that needed to be resolved to prepare for the specific statistical analysis undertaken in this study. In some instances, data was duplicated. For example, projects funded for more than one year, were presented for each year in which they were funded. The data had to be carefully analysed to remove and account for such duplications. There are a number of instances in which similar entries have been formulated differently, eg. 'Botany

Department' and 'Department of Botany'. In some cases, links between different aspects of projects are not clear. The data, once appropriately prepared, provided an important and reliable baseline dataset for this study. Appendix B contains a summary of the key challenges that this study encountered with the data received from THRIP, in order to conduct the proposed statistical analysis.

2.2.3 Phase III – Building a baseline database for the Innovation Fund

The Innovation Fund had no database available. At the time of the study, management indicated that they were unable to make any documents available as these were being audited. An old DACST website contained the names of all the projects funded, the discipline in which they were funded and the names and contact numbers of the higher education beneficiaries. A questionnaire was designed to gather from these beneficiaries the same set of information that was obtained from THRIP. Attached as Appendix C is a copy of this questionnaire. The full population was surveyed, excluding those that were definitely not in biotechnology, ICT and new materials development. A total of 50 questionnaires were sent out and 24 were returned, a return rate of approximately 48%.

The data received from higher education beneficiaries for the Innovation Fund is, in most cases, up to date and needed little follow up, except instances where no contact data was available for higher education beneficiaries.

2.2.4 Phase IV – Surveying industry beneficiaries

This phase aimed to audit industry's perspective and experience of higher education-industry partnerships as incentivised through government-funded programmes. The survey questionnaire, attached as Appendix D, aimed to elicit information on the following:

- The scale of partnership activity in general and then in relation to THRIP and the Innovation Fund partnerships;
- The motives and purposes of engaging in an HE-industry linkage;
- The nature and functioning of the HE-industry partnership;
- The motive(s) for selecting HE or SETI partners;
- The perceived benefits of the relationships funded by THRIP and the Innovation Fund;
- The management of the HE-industry linkage;
- The outputs of the HE-industry linkages;
- The sustainability of the partnerships with HE institutions and SETIs.

A total of 282 questionnaires were sent out to industry partners. They were distributed to those individuals within industry enterprises who were designated as the THRIP or Innovation Fund project contact person. Many enterprises were involved in more than one project. In some cases the same enterprise allocated different individuals for each

project and in others the same individual was designated to several projects. Some enterprises received several questionnaires addressed to these different designated individuals. In projects where more than one industry partner was involved, questionnaires were distributed to all partner enterprises. In projects where different individuals were allocated to projects, each individual was surveyed.

Questionnaires were sent out on 16 October 2002, with the return date set for 21 October 2002. By 20 October, follow-up phone calls were made to the recipients to ensure that they had received the questionnaire and to request that they complete and return the questionnaire by the scheduled date.

On 28 October, a reminder note with a copy of the questionnaire was e-mailed to Innovation Fund and THRIP beneficiaries who had questionnaires outstanding – at that point, the return rate was 14%. Telephone follow-up calls continued until 6 November when another reminder note was sent to those industry beneficiaries that had still not returned a questionnaire. This note indicated that the final return date was 11 November.

The final response rates were such that 61% of the total of THRIP and Innovation Fund projects were covered in the survey returns. 72% of THRIP projects were covered and 46% of Innovation Fund projects were covered. In total, 83 questionnaires were returned, with 60 (72%) of these questionnaires responding to more than one project. A total of 60 questionnaires were returned for THRIP with 50 (83%) responding to more than one project and 14 for the Innovation Fund with one (7%) responding to more than one project. Eight questionnaires were returned by companies that were involved in both Innovation Fund and THRIP projects.

The lower return rate for Innovation Fund projects suggests that industry participants were less willing to participate than those funded through THRIP. Telephonic discussions support this understanding. Industry respondents seemed to have a personal understanding of THRIP and personal relations with THRIP staff whereas respondents from Innovation Fund projects seemed to have little understanding about and a more limited relationship with the Innovation Fund.

2.2.5 Phase V – Undertaking a network analysis

A network analysis was attempted by the University of Cape Town's Department of Statistics. This analysis, based predominantly on a body of literature that attempts to identify linkages between scientists and to define scientific communities, is based on the assumption that a 'working relationship' or 'working contact' indicates a linkage.[2] In the analysis of scientific communities this 'contact' or 'working relationship' is identified through citation with the unit of analysis being the research publication. For the purpose of this study, this analysis was applied to a 'contact' or 'working relationship' defined as two or more researchers, research institutions or companies

[2] Powell (2001) provides a detailed description of the methodological tools of citation analysis and co-citation analysis that provided the basis for the analysis undertaken here.

working as part of the same research team, and the unit of analysis was the project funded by the Innovation Fund or THRIP.

This analysis makes the assumption that an intellectual link exists between researchers or research institutions that work on the same projects. This analysis demanded that the following key steps be undertaken.

A. The establishment of raw matrices

In order to undertake this analysis a number of raw matrices needed to be established. In these matrices the vertical axis lists researchers (or research departments and institutions) and the horizontal axis lists researchers (or research departments and institutions). The following raw matrices were established:

- A raw matrix that indicates the extent to which researchers are working together.
- A raw matrix that indicates the extent to which research departments are working together.
- A raw matrix that indicates the extent to which research institutions are working together.

These matrices enabled the study to determine the extent to which some researchers were involved in more projects than others, as well as the networks (or working relationships) that existed between these researchers and/or research institutions.

B. Developing a co-citation matrix

The next step in this methodological tool is to translate the citation matrix to a matrix that counts the number of times in which researchers (research departments and research institutions) worked together with another researcher, research department and research institution. These matrices exist as a mirror images with the same researchers, research departments and research institutions on the vertical and horizontal axis. The results show the number of times that each has worked with the other. These matrices indicate the number of times that researchers, research departments and research institutions have worked together and develop the preparatory matrices for the correlation matrix.

C. Developing the correlation matrix

The next step in the new methodological tool is to develop a correlation matrix. The correlation matrix is developed by determining a correlation coefficient. The correlation coefficient functions as a measure of how often pairs of researchers, research departments and research institutions worked together. It serves to remove differences of scale between the researchers, specifically between those researchers who worked on many projects and those who worked on fewer projects.

In this study, various spatial mappings were undertaken of the extent to which researchers, research departments and research institutions worked together. This was done by means of multivariate analysis that was used to display inter-research

relationships in similarities matrices. Three kinds of multivariate analysis were tested: Factor analysis, clusters analysis and multi-dimensional scaling. The Statistical Package for the Social Sciences, SPSS-x, provides a clustering programme that implements a variety of hierarchical agglomerate procedures such as: Single linkages; complete linkages and average linking. Multivariate scaling provides an information-rich display of the correlation of linkages.

The correlation matrix, by clustering researchers in terms of both their proximity to each other and their distance from each other, had the potential to provide the study with a description of research relationships existing in the area. However, as indicated in later chapters, the correlations matrix provided an account of networks that are so complex that unfortunately, due to the time and budget constraints of this study, could not be studied in depth. Chapter 10 does however provide some of the initial findings.

2.3 The sample

The sample for this study comprised projects funded by the Innovation Fund and THRIP. The different partners involved in THRIP and Innovation Fund projects require explanation.

Primary beneficiary: This term, applied by THRIP, refers to the main beneficiary or higher education grant holder of each project. The main THRIP contract is a document signed between THRIP and the grant holder at the higher education institution. This term is used throughout this report to refer to the main grant holders.

Secondary beneficiary: In this report, secondary beneficiaries are defined as the industry partners to a project.

Auxiliary beneficiary: In this report, the researchers at HEIs/SETIs who form part of the project research team, are termed the auxiliary beneficiaries.

Students: These include students who work on or are funded through the project.

Primary institution: This refers to the HE institution or SETI that holds the research contract. Effectively, it is the institutional base of the primary beneficiary or grant holder.

Auxiliary institution: This refers to the HEIs/SETIs at which auxiliary researchers are located.

While the focus of this study was on THRIP and the Innovation Fund, an Internet search identified a number of smaller but relevant programmes currently operating in South Africa. These are: (i) The Support Programme for Industrial Innovation (SPII) funded by the Department of Trade and Industry (DTI) and managed by the Independent Development Corporation (IDC); (ii) the Partners in Industrial Innovation Fund (PII), which is also funded by DTI; (iii) the Venture Fund, which provides venture capital to incentivise joint ventures through the DTI; and (iv) the Lead Programmes Fund, which funds innovation through international co-operation. A preliminary review suggests that these programmes all impact, either directly or

indirectly, on higher education partnerships and/or innovation in South Africa. The extent and nature of such impact would, however, require further study. All these programmes represent attempts by the state to steer the national system of innovation in the direction made desirable by the national HE and SET policy framework.

2.3.1 The three technological fields

One of the difficulties facing a project of this kind are the varying definitions of 'biotechnology', 'ICT' and 'new materials development'.[3] A factor complicating this was that prior to 2001, THRIP had not developed a system of analysing proposals received according to subject fields. In 2001, the organisation established a process of peer review of all proposals received and found it necessary to define the proposals according to 13 subject fields that were identified by the NRF to facilitate the assessment of project proposals. These fields are termed, by the NRF, 'technological strategic areas' and are captured in Figure 2.

Figure 2: THRIP's research programmes

1. Forestry
2. Agriculture
3. Animals
4. Business
5. Health
6. Environmental waste management and Biotechnology
7. Food
8. ICT
9. Materials
10. Manufacturing
11. Process manufacturing
12. Mining and minerals processing
13. Power manufacturing and Control Engineering

In terms of the fields outlined in Figure 2, the technological bands of ICT and new materials development have been analysed according to THRIP's categorisation. Identifying projects in the field of biotechnology, however, involved extracting biotechnology projects from four related 'technological strategic areas', namely, agriculture, food, environmental waste management and health. This was done with the support and guidance of THRIP staff.

[3] The HSRC has, as part of Component 1 of the study, commissioned a series of expert papers that develop working definitions of biotechnology, ICT and new materials development.

Figure 3: Innovation Fund and subject area fields

INNOVATION FUND AREAS		
Biotechnology	**ICT**	**Value addition: Materials and advanced manufacturing**
• Molecular biology • Bioinformatics • Genomics • Proteomics • Immunology • Genetics • Molecular modelling • Structural biology	• Systems design and implementation • Information management including content/data analysis informatics, data storage, data integration and information access • ICT application in science and engineering • Enhanced communications technology, including applications in mobile and distributed work environments	• Systems integration (design and engineering) • Net shape & rapid solidification processing • Integrated sensor technologies (sensors technologies with embedded electronics and software) • Materials handling (automatic storage and retrieval) • Advanced materials

The Innovation Fund uses predominantly biotechnology, ICT and value adding as the subject fields for the submission of proposals (Figure 3). In Round 1 of Innovation Fund projects, the category of crime prevention was also included. The Director of the Innovation Fund subsequently indicated that the Innovation Fund also funds projects in Flora and Fauna. This study, in the absence of an available database from the Innovation Fund, focused only on the data available on the DACST website, which did not indicate any projects funded in the area of Flora and Fauna. As such, the Innovation Fund projects in this report were analysed according to the categorisation presented in Figure 3 which includes biotechnology, ICT and a subject field titled value addition: Materials and advanced manufacturing. In addition to applying this categorisation drawn from the DACST website, the technological field was further confirmed in the survey of higher education beneficiaries of Innovation Fund projects which required respondents to indicate the technological field of their project.

It is important to note that the data analysed in this report includes THRIP projects for the years 2001 and 2002 but includes all of the Innovation Fund projects from the inception of the organisation. THRIP projects for 2001 and 2002 were selected as THRIP did not, prior to 2001, collect data on the technological strategic fields of projects. Furthermore, the sample of 2001 and 2002 projects proved sufficient for the purposes of this study. All projects funded by the Innovation Fund since its inception were included in the study to provide for a statistically valid sample size for Innovation Fund projects.