DISCUSSION DOCUMENT

UTILISATION OF RESEARCH FINDINGS
EXTENT, DYNAMICS AND STRATEGIES

NATIONAL ADVISORY COUNCIL ON INNOVATION

SOUTH AFRICA
OCTOBER 2003

A synthesis report based on a contracted project performed by the following consortium of contractors

Access Market International (Johannesburg)
Centre for Interdisciplinary Studies (Stellenbosch)
CSIR/Human Sciences Research Council/
National Research Foundation (Pretoria)
Cyberknowledge Systems (Johannesburg)
Da Vinci Institute for Technology Management (Johannesburg)

DISCUSSION DOCUMENT

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

PREFACE

The fundamental role of innovation and technology in creating and sustaining national growth is increasingly being recognised and understood. This is particularly so as the experience of successful economies accumulates. Such understanding is particularly important in the context of South Africa's need for economic growth, as a basis for job creation and the eradication of poverty. This was clearly brought to light in a recent study on growth and innovation, which was jointly commissioned by NACI and the National Science and Technology Forum.

In the light of this growing understanding, it is crucially important to ensure that national funds, and perhaps more importantly, the nation's scarce high-level human resources, are utilised to best effect. The present study has thus sought to establish the extent to which research findings in South Africa are utilised, as well as the key influencing factors and dynamics involved in the process, so that evidence-based strategies may be developed to increase the utilisation of research findings. The study embraced major research and development institutions across the spectrum of science cultures, including academia, science councils, and industry.

In addition to the important strategic focus outlined above, the present study is consistent with government's drive to ensure the proper management and organisation of its resources, with a view to promoting efficiency and productivity. The results of this study represent a noteworthy contribution in this direction; they also represent a step in the direction of increased transparency and accountability in the management of tightly budgeted public funds.

In regard to the study itself, a few points are particularly noteworthy. Firstly, from the spread of special expertise vested in the many contractors who submitted project proposals, it was clear that there would be merit in arranging for the three distinct phases of the project to be undertaken by different contractors. Secondly, in respect of the final strategy development phase, it was similarly decided that contractors employing completely different approaches to strategy development should be used, and their results then assessed and synthesised into a consolidated set of strategies. This value-adding approach was adopted to increase the prospect of arriving at the best possible outcome. Against this background, it is particularly pleasing to record that the NACI secretariat did an excellent job of co-ordinating and managing the relatively complex project dynamics, as well as the inputs from the five research groups used. A further particularly pleasing feature of the project is that a co-operative, value-adding approach developed between these research groups and the secretariat, as they together sought to achieve a common outcome, which would be of benefit to the National System of Innovation, and the country as a whole. For this, I wish to thank all who were involved.

It should be noted that this report represents a synthesis of the work of all of the research groups, into a relatively short and readable stand-alone document. It has been prepared with the intention of arriving at a report that can be read without having to refer to the individual subproject reports, which together total some 600 pages. The subproject reports, are, of course, available for review or study for those who wish to gain greater insight into the methods used, or the findings achieved by the various research groups.

Finally, it is my sincere hope that implementation of the recommendations contained in this report will lead to findings derived from the country's research effort being increasingly and more effectively utilised, to the equitable and long-term benefit to our Nation.

John Stewart
Convenor: NACI reference group
Pretoria
1 July 2003

EXECUTIVE SUMMARY

This document reports on a comprehensive study on the extent and nature of the utilisation of South African research findings, and suggests strategic steps to improve such utilisation. This report will serve as a basis for the recommendation of policy guidelines to government, research funding agencies and institutions in the national system of innovation.

Motivation

The South African policy on science and technology (S&T) focuses on the need for quality S&T to contribute to addressing the requirements of the country, whether for socio-economic development or improved quality of life. This is the background against which NACI undertook the study. The following considerations led to the study:

- Conceptually, utilisation is a critical hinge in the cross-over between research on the one hand and socially relevant contributions to society on the other.
- However, the government's increasingly outcomes-oriented approach requires that the Department of Science and Technology demonstrate the benefits and impact of public spending on R&D.
- Research utilisation remains a contested area, in which conflicting stereotypes and misconceptions abide.

The study aimed to address these and related issues in the first comprehensive quantitative and qualitative study of its kind in South Africa.

Design of the study

The study was designed to provide empirical evidence of the extent and dynamics of research utilisation, as well as strategies for improvement. It consisted of the following four sequential phases:

- An extensive analysis of the literature and the development of a conceptual model, namely, a **network model of knowledge utilisation**; research utilisation was conceived as outcomes that could take different forms, such as **scientific** utility (for example, applied research), **economic** utility (for example, development of technology) and **socio-political** utility (for example, inputs to policy development).
- A web-based survey of the utilisation behaviour of approximately 11 000 researchers in institutions receiving public funding for research in higher education and the science council system; more than 2 000 completed questionnaires were returned.
- Telephonic interviews on utilisation behaviour in 112 top South African companies.
- In-depth case studies of 12 major research projects.
- Three sets of strategies for the improvement of the utilisation of research findings were subsequently developed from the above information base by three different agencies using different methodologies.
- Finally, a synthesis report was compiled through an iterative interactive approach among the consortium of researchers and NACI.

Main findings

The study yielded extensive databases of detailed information. The following minimum factors promoting research utilisation represent the distillation of those cross-cutting findings from the three empirical studies.

- Demand for specific information and research
- Undertaking research within a matrix of relevant interest groups and a collaborative approach to research
- Larger projects involving more extensive (and adequate) resources
- Recognised research skills, proven experience of and commitment to utilisation by the researcher
- Dynamic and accountable project management
- Institutional acceptance of an innovation policy context that supports the utilisation of findings; appropriate evaluation and reward systems
- Research areas with a history of and need for utilisation, for example, agriculture, recognised national or institutional competitive advantage.

Obviously, the obverse of the above facilitators could be expected to inhibit research utilisation. In addition, the following cross-cutting inhibitors were identified in the empirical projects.

- The lack of appropriately skilled human resources in the country
- The lack of certain equipment and facilities locally
- Inadequate sources of knowledge or information
- The secrecy around intellectual property
- Inadequate government incentives, resources and support
- The conflicting agendas of industry and academia in the context of R&D collaboration and outsourcing.

Strategic recommendations

The three strategy development projects produced more than 40 individual recommendations. These were reorganised by means of a logical framework approach, yielding nine clusters of utilisation strategies, namely:

- Funding
- Institutional support, capacity building and research management
- Research reward systems
- Innovation and commercialisation policies and mechanisms
- Venture capital
- Creation of a utilisation 'intent' in research projects
- User needs
- Collaboration within knowledge production
- Collaboration between knowledge producers and users.

Way forward

The report concludes with a number of pointers to the next steps that should be considered in improving the utilisation of research findings, with a view to contributing to South Africa's socio-economic development. It proposes a differentiated implementation plan that takes into account the various strategy domains, levels of application in the national system of innovation and stages in the research and innovation process. The following modest framework for implementation, consisting of an outline of instruments, is recommended.

- *R&D utilisation charter*: The first proposal is that an R&D utilisation charter be established for voluntary adoption and implementation by all organisations undertaking research. The charter would set out the principles that need to be accounted for in the planning and execution of research in due course to optimise the utilisation of the research findings that emerge. The principles would reflect the essence of the wide spectrum of findings of the present study, which can be implemented by the executive management of such institutions. It would thus become the responsibility of management to appropriately handle the different dimensions considered earlier. It should be promoted for voluntary adoption by all organisations that undertake or fund research and technology development, both within the public and private sectors.

  While the charter would set out a clear statement of the principles, there would need to be flexibility in the manner in which the principles are implemented in practice. It would thus be appropriate to supplement the charter with guidelines in those key areas where such guidance would facilitate and foster implementation of good practice, and the findings of the present study.

- *Policy directives on research funding and management*: Many of the recommendations offered in this report can only be implemented by government. Accordingly, it is proposed that those strategic objectives and recommendations accepted by government be further developed by the Department of Science and Technology into a set of policy directives. Given that a number of these policy directives would, if adopted, impact on, and require the support of other government departments, considerable consultation and collaboration with these departments would be required in the development of these policy directives.

- *Guidelines on performance management and project funding*: Where necessary, guidelines may be required for the effective implementation of the performance management and project funding principles of the R&D charter. Such guidelines would draw heavily on the experience of the case studies, other findings reported in this study and the input of experts from affected organisations. The guidelines would follow the usual style of putting forward the issues that need to be considered, as well as providing examples of established good practice, but in a non-prescriptive manner.

- *Sectoral networks of innovation*: A further proposal is that consideration be given to the creation of Sectoral Networks of Innovation Programmes (SNIPs). These networks should be created as collaborative initiatives between knowledge producers, various government and industry sectors and final end-users. Close interaction and collaboration among stakeholders is essential to guiding the development of research agendas, as well as increasing the capacity of industry and end-users to absorb the technological or social advances.

- *Knowledge map*: It is proposed that a national knowledge map be developed and maintained to identify the gaps and opportunities for conducting research and development that has strong utilisation potential. In many respects, the Technology Foresight Project, conducted a few years ago by the Department of Science and Technology, may be seen as having already initiated the creation of the envisaged knowledge map.

- *A dynamic knowledge repository of South Africa's knowledge base*. Such a repository should represent the strategic knowledge and innovation priorities and challenges of the country. The ultimate aim and value of such a knowledge repository would be to encourage knowledge sharing among producers and users of research through the creation of several information channels, or pathways, through which researchers and potential users can interact.

- *Knowledge utilisation barometer*: This NACI study on the utilisation of research findings has, to some extent, established a baseline of the extent of knowledge utilisation in South Africa. An instrument to provide ongoing monitoring and evaluation of the extent of utilisation would have obvious advantages and it is therefore recommended that such a barometer be developed. It should meet criteria, such as being conceptually grounded in the NACI study and it should further comply with standard requirements of validity, reliability, cost-effectiveness, etc.

In conclusion

This NACI study on the utilisation of research has produced comprehensive and detailed information on the state of utilisation in the South African system of innovation as well as on a wide range of desirable strategies for improving both the quantity and quality of research utilisation. The proposed strategies and implementation instruments are consistent with various recent government initiatives, for example, to increase research output, to improve the responsiveness of higher education to national goals, and to align the research of science councils more with macro-economic concerns. We believe that this study not only provides a strong rationale for the intrinsic value of utilisation-focused research and development, but also outlines a number of realistic ways of achieving this goal.

INTRODUCTION

This study came into being in response to the National Advisory Council on Innovation's (NACI) interpretation of an overarching objective of the South African innovation policy, namely that S&T should contribute to the development of the country. A tenet underlying this objective is clearly that research findings should be converted into solutions to real problems and thereby contribute towards improving the quality of life of South Africans and supporting sustainable economic growth – in short, research findings should be utilised. The *White Paper on S&T*, for instance, describes innovation as "the production of new knowledge and its creative application in a number of spheres" (RSA, 1996). Currently, the South African government increasingly insists on getting answers to the key question of expected outcomes and impacts of the investment of public money – including the investment in science and technology (see Chapter 1).

The challenge, however, was that very little is known about the extent of utilisation, its dynamics or of how to promote it.

The topic has received little attention in South Africa so far. The last local study was done in 1984-1989 by NACI's predecessor, namely the Science Advisory Council. Although those reports still contain useful perspectives, the fact of the matter is that science policies and the total research environment have undergone such fundamental changes – here and internationally – that a new study was essential.

Scope of the study

On 22 February 2002 NACI approved the study, which would determine "the extent to which research findings are actually utilised and mapping the dynamics of the process of utilisation (as) conditions for the formulation of strategies on the optimisation of the outcomes of the national R&D effort". A call for proposals was published in the national papers on 29 March 2002 and the first contracts were signed in July 2002.

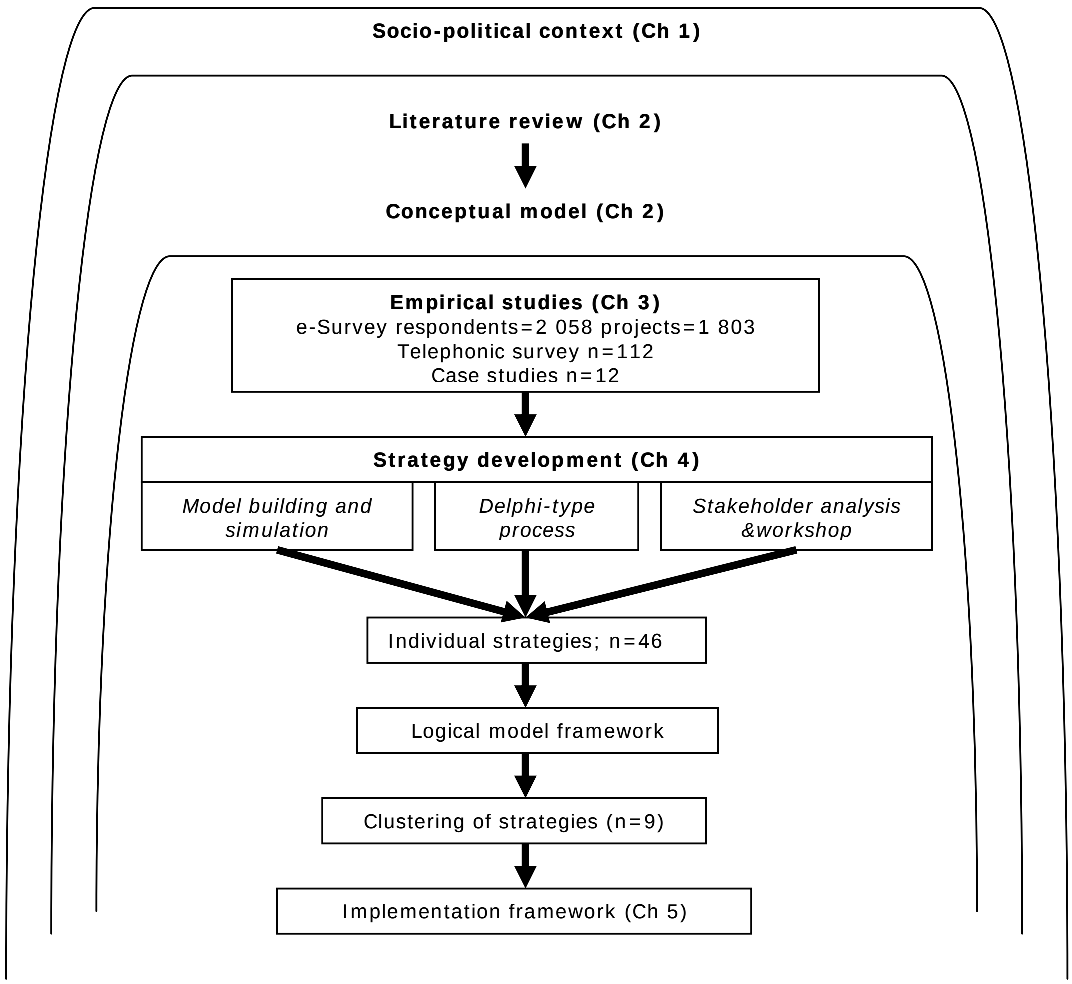
Design of the project

Given that the issue of utilisation of research findings is still a contested area in certain quarters of the National System of Innovation (NSI), the project was designed as one of evidence-based policy development. The trend of evidence-based policy is growing in industrialised countries, where various forces (e.g. participatory democracy, the basic premises of a knowledge economy and society, the Internet, etc.) no longer allow governments to promulgate policy, without a valid information base and extensive consultation.

The design of the study can best be described as a multi-perspective empirically based strategy development approach. The process consisted of a literature study, an e-survey of projects in science councils and higher education institutions, telephone interviews with the respondents in the business sector, three strategy development projects and the compilation of this synthesis report. This process and the structure of the report are shown in the following figure.

Figure 0.1 shows that the broad model of utilisation, albeit in slightly modified versions, was used as the conceptual framework for all subsequent phases (i.e. subprojects). The empirical findings were similarly used as input to the three strategy development subprojects.

Figure 0.1: Structure and process of the project



Information on the outputs of the study should help specify the extent and the organisation of the project; these are reflected in Table 0.1 on the next page.

This report

Three primary guidelines were followed in drafting this report, namely

- It should be a 'stand alone' report
- It should be value-adding, in that it should be more than a mere summary of the individual sub-project reports
- It should be as concise as possible.

All the participants in the project commented on the drafts and the end product was accepted by NACI in July 2003.

It is important to point out that NACI will use this report as a basis upon which to launch a number of subsequent initiatives. Firstly, the report will be used as source for a submission on policy guidelines to the government. Secondly, an international conference is planned and, thirdly, a series of regional seminars is also considered. It is further anticipated that the members of the consortium will disseminate their project reports to relevant audiences.

Table 0.1

Outputs of the project

Focus	Methodology	Title of report	Other outputs	Contractor / Authors
Conceptual	Literature study	*Research utilisation: Literature review and conceptual framework*	Bibliography	CENIS, US
Extent of utilisation: HE & SC	e-Survey Σ=11 850 N=1 850	*A survey of research utilisation*	Quantitative database	CENIS, US
Extent of utilisation: Business	Telephonic survey N=120	As above	Archive of transcriptions	CENIS, US
Dynamics of utilisation	Case studies N=12	*Utilisation of research findings: Case study report*	Archive of transcriptions	CSIR/HSRC/NRF
Strategy A	Model building and simulation	*Strategy for improving research utilisation*		CyberKnowledge Systems
Strategy B	Delphi-type process, using an expert panel of 7	*Strategy for improving the utilisation of research – Expert panel approach*		Da Vinci Institute of Technology
Strategy C	Stakeholder analysis (n=22) & workshop of 7 representatives	*Strategy development Stakeholder analysis*		Access Market International
Synthesis	Iterative interactive approach culminating in synthesis position	*Utilisation of research findings in South Africa: Extent, dynamics and strategy*		NACI

CHAPTER 1

THE SOCIO-POLITICAL CONTEXT OF INNOVATION IN SOUTH AFRICA

1.1 Policy focus after 1994

The first democratic government of South Africa, while concerned with redressing the legacy of apartheid also recognised the strategic value of a country's ability to understand, interpret, select, adapt, use transmit, diffuse, produce and commercialise scientific and technological knowledge. Based on policy research and negotiations involving a wide range of interests, a Ministry was created to oversee the transformation of this portfolio of activities, and the Department of Arts, Culture, Science and Technology (DACST) was therefore established in 1994. DACST published a White Paper on Science and Technology in 1996 that introduced the concept of a National System of Innovation (NSI) as the organising framework whereby South Africa's considerable knowledge resources would be reviewed, restructured and harnessed for reconstruction and development. Simultaneously, government also published its Growth, Employment and Redistribution Strategy. which laid the basis for the country's macro-economic reform efforts.

The second post-apartheid government continued the established macro-economic stance, and based on the aggregate fundamentals achieved, declared that the country was sufficiently stable to embark upon the more detailed tasks of micro-economic reform. Unpacking the micro-economic reform strategy, through a series of government cabinet *lekgotlas*, led government to identify research and development as a cross-cutting driver. The now focused Department of Science and Technology (DST) in 2002 published *South Africa's national research and development strategy* (NR&DS) as a contribution to the micro-economic reform process. The NR&DS proposes that science and technology (S&T) is an enabling driver of economic growth and social development, thereby contributing to improving the quality of life of all South Africans.

1.2 R&D strategy within the NSI

The NR&DS builds upon the *White Paper on Science and Technology* by using the National System of Innovation approach. It explores the ways inwhich the South African economy acquires technology, the intensity of the domestic technological effort and the associated level of human resources for science and technology (HRST). Through an analysis of the relationship among these factors, the NR&DS suggests that an "innovation chasm" exists within the system. In response to this negative situation, it promotes a strategy of enhancing the efficiency of the system through dedicated S&T missions.

A national system of innovation derives from its objective of fostering development, application and diffusion of science and technology to improve productivity and growth potentials. Chris Freeman describes anNSI as "the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies" (1987: 1). By using this systemic description, he argues that "(t)he rate of technical change in any country and the effectiveness of companies in world competition in international trade in goods and services, does not depend simply on the scale of their Research and Development and other technical activities. **It depends upon the way in which the available**

resources are managed and organised, both at the enterprise and at the national level. The NSI may enable a country with rather limited resources, nevertheless, to make very rapid progress through appropriate combinations of imported technology and local adaptation and development. On the other hand, weaknesses in the NSI may lead to more abundant resources being squandered by the pursuit of inappropriate objectives or the use of ineffective methods" (1987: 3).

1.3 NSI as networked model

The NSI concept succeeds the previous thinking in science policy that saw a linear relationship between fundamental research, applied research and application. The networked model of an NSI seeks to understand the numerous feedback loops that operate within and among relevant firms and institutions. The periodisation of policy changes listed above conforms to a global shift in thinking about the nature and impact of S&T on the developmental status of nation-states. David and Foray point out that "*nowadays disparities in the productivity and growth of different countries have far less to do with their abundance (or lack) of natural resources than with their capacity to improve the quality of human capital and factors of production: in other words, to create new knowledge and ideas and incorporate them in equipment and people*" (2002: 1). Literature based on economic analysis of cross-country differences in per capita income and growth confirms that they are driven largely by differences in Total Factor Productivity, which is generally associated with technological progress.

The study of the National Science and Technology Forum and the National Advisory Council on Innovation (NACI) study on growth and innovation in South Africa also indicates a positive trend along the lines of the global tendency (2000). To fully appreciate this quantum change in the current mode of production, it is necessary to restate a few essential concepts from earlier South African policy work as well as the *raison d'être* for this exercise.

Firstly, our work is essentially concerned with how to maximise the return on investments in research and development (R&D). While this is a generic aspiration even on a global stage, the enormity of the inherited inequities of apartheid and, more specifically, the dualism in the structure and composition of our economy offers us a well-defined set of parameters to understand the scale and scope of the problem.

Secondly, the import-substituting industrial strategies of the apartheid regime were unsustainable and with the exception of the weapons programmes, synfuels and energy production, ensured a reliance on limited value-addition activities and primary sector exports (especially minerals). Coupled with sanctions, including the academic boycott, these features tended to blunt the competitive pressure experienced by firms and research institutions (science councils and higher education institutions).

Thirdly, the democratic government was required to marshal resources to meet the needs and aspirations of a population of 42 million, rather than limiting its efforts to meeting the needs of previous white laager and its associates, totalling some 8 million, as the apartheid government had done. However, the need for an expansion in the quantity and quality of public services in South Africa occurred in a global context that was not necessarily favourable to such expansionary policy perspectives. While trade is touted as the elixir to remedy constraints to growth, the global marketplace is divided along established regional entities. Subsidies in the North pervert markets to the detriment of developing countries, and increasing displays of unilateralism consign the need for a rules-based multilaterally negotiated system to a lower order of priority.

Nasierowski and Arcelus (2003) argue that whereas R&D policies are certainly an important contributor to productivity growth, variations in national productivity growth cannot be entirely explained by dissimilarities oin the various countries' R&D policies. According to their analysis, market distortions also account for an important portion of these variations. These factors also need to be considered as we engage in ensuring that our available S&T resources are better managed and organised.

1.4 The need for relevance and efficiency

These structural conditions are being experienced as the publicly funded institutions of the NSI are being driven towards greater relevance and higher levels of efficiencies. While these trends are not mutually reinforcing, they can also be debilitating in terms of ensuring the throughput of achieved efficiencies into enhanced levels of productivity. The main components in ensuring a "better managed and organised" system relate to efficiency and productivity. "Efficiency" refers to ability of the NSI to transform R&D inputs into R&D outputs, while "productivity" is contingent upon the realised vaue of the output and its incorporation into an expanding production function. The productivity change experienced at a national level would serve as a proxy for the success of this transformative process.

Sanjaya Lall, in a forthcoming publication (2003), lists South Africa as 'moderate' in terms of its technological effort (the index of the average standardised values of productive enterprise-financed R&D and patents per 1000 people). South Africa is the only state in sub-Saharan African to fall into this group. In Lall's industrial performance index, South Africa is included in the "medium-high" category. In terms of high technology exports per capita and total electronics exports, South Africa is in Group 2. The index positions achieved by South Africa in all the rankings illustrates the sophistication of the South African industrial landscape. This is not restricted to capacity, but fundamentally driven by export performance.

This observation prompts the questions: What are the barriers to further growth? Do these barriers include a shortage of middle-level management, a dearth of local skills, over-regulation of labour and business, the high cost of telecommunications, the congested transport system, or a lack of relevant high quality research?

This study seeks to understand the dynamics of research and the complex relationships governing the utilisation of research findings across a range of contexts covering the research disciplines, institutions and clients.

It is universally recognised that making the codified knowledge resulting from research relevant and framing it in an accessible format, is critical to increasing the potential for utilisation. Knowledge- and research-intensive communities are agents of economic, social and political change insofar as the knowledge that they produce is valorised. This enables a virtuous circuit of utilised knowledge, determined by well-defined user-specificities and intensity. It must, however, be recognised that there is never any guarantee that research will be translated into practice. As Sharpe (1977: 45) puts it, '"We are brought face to face with the fact that it has proved very difficult to uncover many instances where social science research has had a clear and direct effect on policy even when it has been specifically commissioned by government.' This is even truer of fundamental research in physics or pure mathematics. Contemporary evidence shows that in the new crossover fields such as genetic engineering, innovation is realised in a far shorter time, and there is a much stronger link between patents and academic research, as codified in journal publications.

1.5 The imperative of innovation

The application of an innovation after its initial development constitutes a central pillar of a virtuous knowledge circuit. At an institutional level, it enables a productive relationship between science and industry/society. At a sectoral level, it cements the public-private partnerships necessary for accelerated growth and development. The caveat remains "... if the public effort is not followed up by private firms, the scientists trained in the universities will emigrate, and the research performed by public laboratories will be stifled or its results will be taken up and developed by firms abroad" (OECD, 1992: 43).

Chapter 2 of this report is devoted to a brief overview of different models of research utilisation, as well as the most widely accepted definitions of utilisation.

CHAPTER 2

CONCEPTUALISING RESEARCH UTILISATION

2.1 The concept of innovation

Knowledge innovation is the creation, exchange, evolution and application of new ideas into marketable goods and services for the success of an organisation, the vitality of a nation's economy, and the advancement of society as a whole.

Research and development is an integral component of the innovation process. Our focus is on how the results and findings of R&D are transformed into useful applications and products. Before we discuss how different models of research utilisation have developed over the past forty years, we sketch the larger science policy context against which these models have emerged.

2.2 An overview of R&D paradigms

Shifts in approaches to the utilisation (in other words, the recognition, implementation and uptake) of public research must be understood against the background of larger paradigm shifts in public sector R&D worldwide. In this respect, there is remarkable convergence of opinion in the literature regarding the major trends in most industrialised countries over the past five decades. Well-known scholars such as Henri Averch, Stuart Blume, Aant Elzinga, Christopher Freeman, Arie Rip and others concur, not only about the periodisation, but also about the main trends and shifts that characterise public sector R&D in the post-war period.

In her overview, Ruivo distinguishes three main paradigms. The first paradigm, which was introduced by the publication of Vanevar Bush's classic report, *Science: The endless frontier*, placed the emphasis on basic science and a model of technological innovation that assumed that the sheer volume of growth in basic science would be sufficient to continuously feed technological innovation. This optimism towards the potential and utility of science was fuelled and reinforced by widespread economic growth in many countries of the world. However, by the late 1960s and early 1970s, events such the Vietnam War, growing environmental concerns and economic recessions, led to a new skepticism and even disillusionment with science. This resulted in inevitable cuts in public funding of science and a demand for greater accountability with respect to the value and benefits of science. As far as R&D was concerned, there was a clear shift towards more applied and problem-solving science. The associated model of technological innovation remained linear, but with a fundamental shift towards the demand side, i.e. the interests of business and industry (the main users of science) now defined the agenda for public-funded R&D.

Various criticisms of the linear model of technological change, as well as what was regarded as an oversimplified view of science, led in the mid-1980s to the emergence of the third paradigm. The rise of the global (networked) economy and the internationalisation of trade also impacted significantly on the way in which science was conducted and diffused worldwide. This paradigm attempts to capture more of the complexity of science (understood according to the notions of both 'strategic science' and 'Mode 2 knowledge production') as well as a more interactive and systemic interpretation of the dynamics of technological innovation. The key features of each of these paradigms are summarised in Table 2.1 below.

Table 2.1: Trends in international R&D

	Paradigm	Economic	Contexts (National and International)	Model of technolo-gical change	Topical issues	Types of research
1945 to 1970	Science as motor of progress	Big boom	Prestige, scientific co-operation	Linear model (science push)	Choices re. 'big science'	Basic
1970 to 1985	Science as a problem solver	Economic recession/ Crisis	Industrial competitive-ness	Linear model (demand pull)	Economic growth and competitive-ness	Applied
1985 –	Science a source of strategic opportunity	Network economy/ globalisation	Managing inter-dependence	Complex model: diversity of institutions/ processes	Strategic opportuni-ties; long-term needs incl. science base	Strategic/ Mode 2

2.3 Models of knowledge utilisation

Following our brief introduction above, we present a similar (although not identical) threefold categorisation of models of knowledge utilisation. We refer to these three as the **science push** model, the **user-driven** model and the **network** model of knowledge utilisation.

2.5.1 Science push model

The science push model of knowledge utilisation coincided – not surprisingly – with the more general science push model discussed above. Its basic premise can be stated as follows: The **supply of advances in research (findings)** is the major determinant of knowledge utilisation. The researchers are the sources of ideas for directing research, and users are (simply) receptacles of the research results. This means, therefore, that utilisation follows a linear sequence from the supply of research advances to utilisation by decision-makers and practitioners.

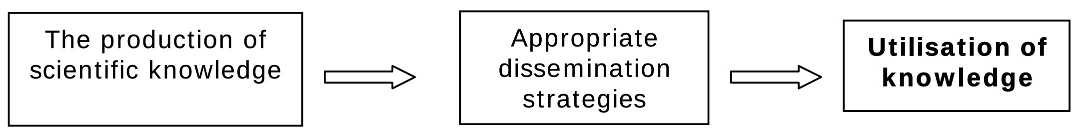
Within this framework, the more detailed discussions in the literature focus on which of the dimensions of the production of science could lead to more or less effective utilisation. Dimensions that have been studied over the years include content attributes (the quality and credibility of the research produced); types of research (basic/applied), and differences between research domains and disciplines.

Two main critiques were ultimately advanced against the science push model: Firstly, it was argued, that the transfer of knowledge to users is not automatic in a context where no-one assumes responsibility for its transfer. Merely stating that more science and advances in knowledge production will generate their own momentum which in turn will lead to research dissemination and ultimately to the utilisation of research findings, underestimates both the complexity of the process and the often conflicting interests of the various stakeholders in S&T.

Secondly, unprocessed research information is not usable knowledge – a process for transforming it into usable knowledge is required. The latter critique led to the development of a variant of the science push model, referred to in the literature as the dissemination model. According to this model, a step should be added to research activities by developing dissemination mechanisms to identify useful knowledge and transfer it to potential users. Dissemination is deemed to occur only when a potential user becomes aware of the research results – the potential utility of science first has to be recognised before it can or will be applied. In many cases, the products of research are never widely disseminated and thus have little significant impact.

In summary then, knowledge utilisation in the expanded science push model, is explained with reference to two determinants: the types of research results (the original science push model) and the dynamics of the dissemination process. These two main features of the science push model are illustrated in Figure 2.1 below.

Figure 2.1: The science push model of knowledge utilisation



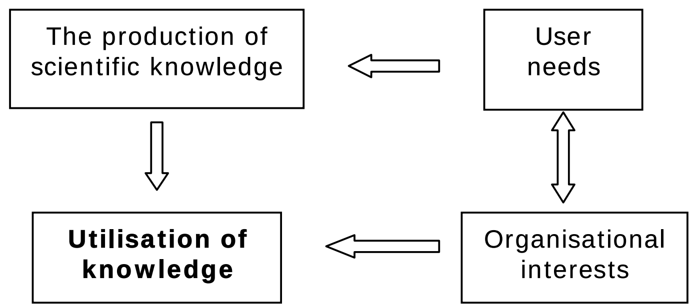
2.5.2 User-driven model

As was soon argued, however, that the mere receipt of knowledge by the potential user does not necessarily imply its use. The lack of interaction between knowledge producer and knowledge user was identified as the main problem affecting the under-utilising of research. The main shortcoming – even of the expanded science push model – was that potential users are not involved in either the selection of the transferable information or involved in the production of the research results. This led in the early 1970s to the emergence of a more user- or demand-driven approach to utilisation.

The basic premise of this model can be formulated as follows: **The users of research are regarded as the major sources of ideas for directing research**. This approach generates a 'customer-contractor' relationship, in which practitioners and decision-makers behave like 'customers' who define the research they want, and the researchers behave like 'contractors' who execute contracts in exchange for payments. It should be pointed out that this is still essentially a linear sequential model, which in this case starts with the identification of the research problem by the customers or potential users. In the user-driven model, knowledge utilisation is best explained (only) by the needs of the users. It is argued that the use of knowledge is increased when researchers focus their projects on the needs of users instead of focussing only, or primarily, on the advancement of scholarly knowledge.

One of the more persistent criticisms of this model also led to an adaptation of the model. The criticism pointed to the fact that even research geared to solving problems may be ignored or pushed aside by the potential users because it may conflict with their organisational (and other) interests. The emphasis on organisational interests meant that organisational structures, rules and norms were increasingly regarded as essential determinants of knowledge utilisation. The principal factor affecting the under-utilisation of research was identified as the political interests of the users, and a possible conflict between those interests and the research findings. Stated differently: research results (at least in the social and health sciences) are more likely to be used when they support the interests and goals of the organisation. Figure 2.2 captures the key aspects of the user- or demand-driven model.

Figure 2.2: User-driven model of knowledge utilisation



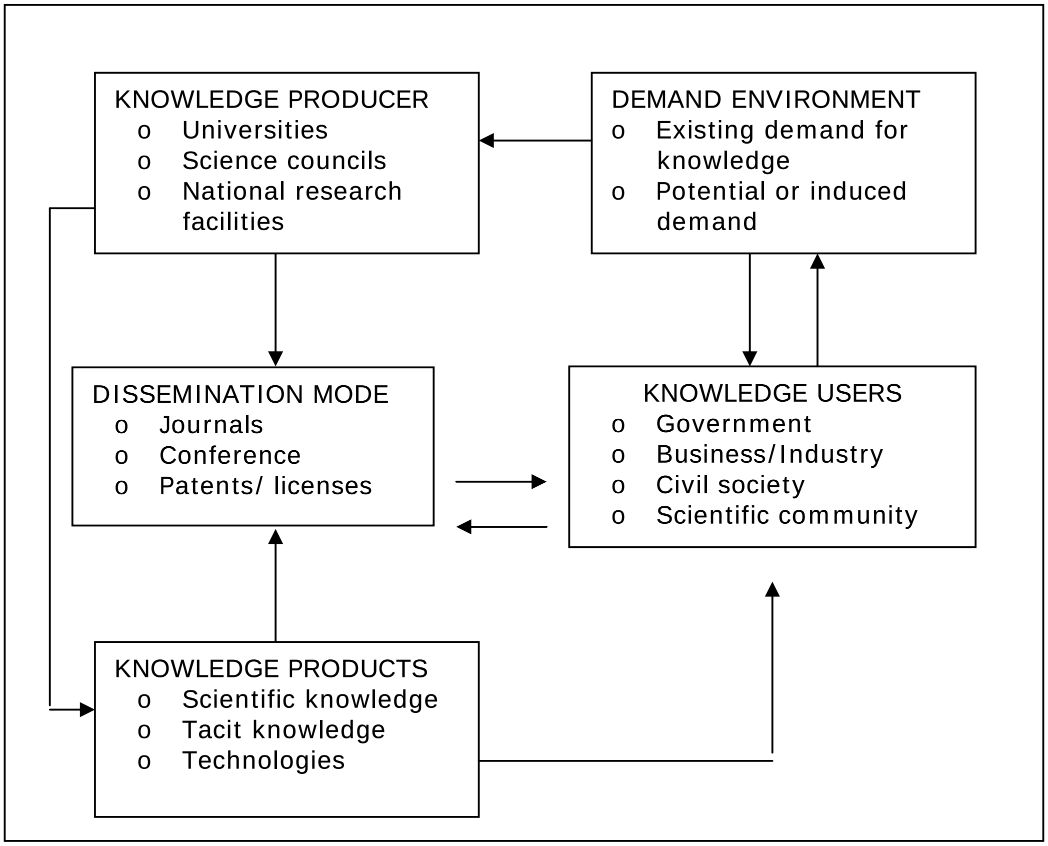
The user-driven model was not without its critics, however. Three main criticisms were levelled against this model: Firstly, it was argued that the model focuses largely on the instrumental use of research and neglects to take into account that different types of knowledge lead to different uses. Secondly, it was argued the moldel over-emphasises the 'egotistical' interests of users. Thirdly, the model was said to omit the interaction between produces and users of research findings. The first criticism is discussed in Section 2.3 below in which the various notions of research utilisation are explored more systematically. The second and third criticisms led to the development of what we will refer to as the 'network' model of knowledge utilisation discussed in the next section.

2.5.3 Network model

According to the network model, **effective knowledge utilisation depends on various 'disorderly' interactions occurring between researchers and users**. The model predicts that the more sustained and intense the interactions and collaborations between researchers and users, the more likely research findings are to be utilised. The model gives greater attention to the relationships between researchers and users at the various stages of knowledge production, dissemination and utilisation. There is more of a focus on the nature of the linkages and other interactive mechanisms that bind producers and users of knowledge (as well as other potential stakeholders) into a system of knowledge and innovation. Linkage mechanisms include informal personal contacts, participation in committees, and transmission of reports to non-academic organisation. The key issue in this model is basically the 'intensity' of linkage mechanisms.

Barry Bozeman's (2002) model of technology transfer is a good example of the network model of technology transfer. We have adapted it somewhat into a more generic systemic model of knowledge utilisation.

Figure 2.3: Adapted Bozeman's model of knowledge utilisation



2.3.4 Summary

To summarise, the network model of knowledge utilisation incorporates all of the features of the science push and user-driven models. This allows the dynamics of knowledge utilisation to be explained with reference to three sets of factors:

- Types of research, scientific disciplines and dissemination strategies (Expanded science push model)
- Needs and organisational interests of users (User-driven model)
- Linkage mechanisms and forms of collaboration (Network model)

In our discussion of the user driven model, we pointed out that one of the criticisms leveled against this model was its narrow instrumentalist interpretation of knowledge utilisation. In our final section on conceptualising utilisation, we discuss how the notion of utilisation has been broadened over the years to the point where a more encompassing notion is now widely accepted.

2.4. Broad and narrow definitions of utilisation

The term 'research utilisation' can be understood in either in a **narrow** or **broad** sense. In the narrow sense, the utilisation of research refers to the economic or commercial utility of research (in other words, the usefulness of science for economic growth or commercial aims, such as the development of new technologies). In the broad sense, research utilisation refers to any form of use to which scientific research and its results are put. So, in addition to economic or commercial utility, we could also include social utility (use of research for society at large, e.g. the design and development of social interventions) and political utility (science in support of political decision-making, e.g. the development of a new health policy).

Even this broadening of the meaning does not cover all possible forms of research use. We also need to remind ourselves that science (at least 'basic' or 'fundamental' science) is first and foremost aimed at the advancement of knowledge and increasing our understanding of the world. Some would argue that a fundamental science paradigm does not intend or anticipate that the findings will be utilised. This is only true if 'use' is understood in the narrow sense of 'economic' or 'socio-political' use, but fundamental science is, of course, used by other scientists. One scientist 'uses' another's findings, or uses a model or framework developed by another. We often talk about 'applying' the insights gained in one study to another. We will refer to this as the scientific utility of research: research for the sake of advancing knowledge.

Another useful distinction is that between the **direct** (immediate) and **indirect** (mediated) uses of research. Research (findings) are often used immediately, for example, when advice is given and acted upon, when research is used to inform decision-making, or when research leads to changes in an existing technology or the development of a new one. In all of these cases, there is a clear 'causal chain' or 'causal network' that links the publication or dissemination of the research to the ensuing decisions.

Very often, however, research is published and made public in various forms without any immediate uptake. The findings may lie dormant in the public domain until some time in the future when they are 'rediscovered'. This applies to scientific, economic and socio-political uses of research. There are many examples of scientific ideas which are not immediately appreciated and applied/used but only later taken up by the scientific community (Wegener's continental drift theory is a good example). Similarly, scientific ideas – especially in the social sciences and humanities – sometimes follow indirect routes of diffusion and take a long time to be applied in a social, economic or political sense. Carol Weiss's well-known phrase 'knowledge creep' is a good description of such indirect utilisation. Weiss (1980) observes that research usually influences policy in diffuse ways – it provides "a background of empirical generalizations and ideas that *creep* into policy deliberations". Another example is the way in which social science terms such as 'Freudian slip' or 'paradigm shift' have eventually become part and parcel of everyday discourse, and are now used in contexts very different from the original intentions of their authors.

The notion of 'utilisation' logically presupposes that the utility/usefulness of research has been recognised by a user or users. The notion of 'use' (as opposed to 'awareness') implies some action. We become aware, or are made aware, of new scientific discoveries or inventions. However, in applying or using other scientists' work, we have to take an action; which involves a deliberate decision on our part.

Finally, we can distinguish between **intended** and **unintended** users of research. Research is often used by the originally intended users(for example, a contracting agency, government department or commissioning firm). However, research – which is mostly in the public domain – can in principle be appropriated and applied by anyone that finds it useful. This is especially true when we refer to the scientific utility of research. Scientists do not usually have specific scientists in mind when disseminating their research findings to the larger scientific community. Even if they have a particular disciplinary grouping or theoretical paradigm in mind, it does not prevent any other scientist or scholar from using, applying and even adapting those findings as they deem useful.

The distinctions made thus far are summarised in Table 2.2 below.

Table 2.2: Utilisation: Conceptual distinctions

FORMS OF UTILITY	INTENDED USERS		UNINTENDED USERS	
	Immediate/direct use	Mediated/ indirect use	Immediate/ direct use	Mediated/ indirect use
Scientific utility	Applied research		Basic research: Immediate scientific uptake	Basic research: Medium- to long-term scientific uptake (e.g. Wegener)
Economic utility	Technological (product and process) development	Technology imitation	Technology diffusion/ Knowledge spillovers	
Socio-political utility	Policy development/ social technologies (e.g. scenarios/ tests)		Basic strategic research: Immediate social and political uptake	Knowledge creep: Diffusion into society

The summary above should not be interpreted to mean that there are hard and fast boundaries between intended and unintended users, or between immediate and mediated use. These factors clearly exist along a continuum. At one end of the spectrum, forms of research utilisation are immediate: scientific advice and consultation, a technical briefing, a presentation to a scientific or non-scientific audience, and so on. At the other end, research findings seep into knowledge systems and other social systems slowly and in complex ways. The transfer of sophisticated technologies from the producer to the ultimate end-user is a complex process, which involves overcoming many obstacles (financial, legal, social, cultural, institutional) as well as the engagement of multiple stakeholders.

2.5 Concluding comments

This concludes our very brief overview of the history and nature of models of knowledge utilisation, as well as other important conceptual distinctions regarding knowledge utilisation. In Chapter 3, we report on the empirical findings of the survey and case study components of the study, following largely the determinants of knowledge utilisation identified in the network model. In the final chapter on utilisation strategies, we again apply the same conceptual distinctions in our discussion of possible interventions aimed at improving knowledge utilisation.

Chapter 3

Empirical Findings

The findings reported and discussed in this chapter are based on a wealth of data collected through the electronic survey, telephone interview and case study components of the study.

An electronic, web-based survey of R&D performers in the public sector (universities, technikons, science councils and national research facilities) was conducted during the second half of 2002. Approximately 8 000 questionnaires were distributed to university and technikon researchers and a further 2 859 were sent to science councils. The total number of 2 058 completed questionnaires represents a response rate of approximately 20%. Table 3.1 below summarises the main characteristics of the realised sample.

Table 3.1: Survey respondents and research projects by sector of R&D performance

Sector	Respondents		Projects	
	N	%	N	%
Science councils	625	30	539	30
Universities	1192	58	1081	60
Technikons	241	12	183	10
Total	2058	100	1803	100

Telephone interviews were conducted with 116 top South African companies in September and October 2002. The reports of 112 of these interviews were usable. All interviews were transcribed and subsequently analysed using Atlas/ti. Table 3.2 presents a list of interviews by economic sector. The full list of companies interviewed is included in Appendix 1.

Table 3.2: Industry interviews by sector

Sector	No. of interviews
Agriculture, forestry, fishing and hunting	10
Chemicals	21
Construction	2
Electronic hardware, systems & software	16
Fabricated metal products & machinery	22
Manufacturing	22
Mining	12
Services and infrastructure	5
Transport	2
Total	112

The third set of empirical data reported on here, was collected through in-depth case studies of 12 major research projects. Table 3.3 lists the case studies.

Table 3.3 Coverage of the case studies

Project	Lead organisation	Year started	Type of research	Main outputs
Tobacco control	National Health Promotion R&D Group, (MRC)	1995	Applied	National policy/ Research papers Conference papers/ Education outreach Human resources
Institute for Wine Biotechnology (IWBT)	IWBT, University of Stellenbosch	1995	Basic and applied	Human resources / Research papers Conference papers/ Patents
Foresight	DACST	1995	Use of several consultative processes	Reports/ Networks Presentations
Fundamental processes in mining-induced fracturing	Miningtek, CSIR	1999	Basic and applied	Research papers Models Human resources
Plastic waste utilisation	Centre for Polymer Technology (CPT) CSIR	1998	Technology adaptation	Adaptation of technology
Renewable energy	Aerotek CSIR	1996		Initial intention was to develop a GIS-based (geographical information system) planning tool. A generic tool was developed
Power quality compensator	Technology Services International Eskom	1996/97	Applied	QuPS
Heavy vehicle simulator	Transportek CSIR	2000	Applied	Guideline documents
Crime analysis and decision support	CSIR, HSRC and MRC	1998	Applied	Reports/ International presentations Book chapter/ Television programme presentation
Genetically engineered crop improvement programme (GENCIP)	CSIR	1993	Basic and applied	Reports Human resources development
Gold recovery process	Mintek	Around 1992	Applied	Gold refinery technology
Polymeric materials	US Institute for Polymer Science	2000	Basic and applied	Graduated students Industry products

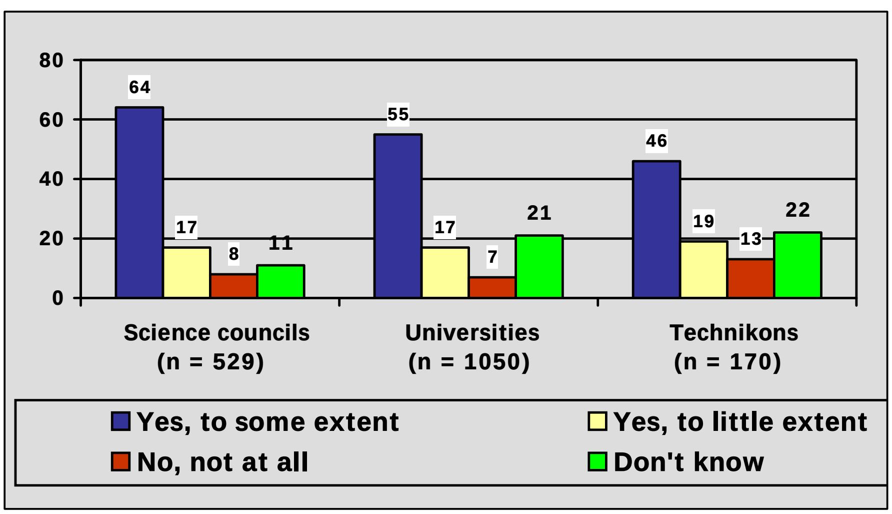
3.1 The survey: Key findings

A social survey is a self-report measure: we ask respondents to respond – as reliably as possible – to a set of questions. In this case, our aim was to establish whether the research findings of a particular research project or programme have, in the opinion of the project leader, been implemented or utilised. Given the complex nature of the diffusion and utilisation of research, it is likely that project leaders may not always be aware of the full extent of the use or uptake of their research. This implies that 'self-reported' utilisation may not provide a very accurate picture of actual utilisation. The project leader's lack of awareness or knowledge of all the possible applications and uses of his or her research could lead to under-reporting. Conversely, given the obvious interests and possible bias in citing positive utilisation, the project leader is equally likely to over-estimate utilisation. Short of doing a detailed 'audit' of all the most likely users of a representative sample of major projects, we have to accept these limitations – applicable to all surveys - and interpret and apply the results of the survey with caution. Having said this, the more than 2 000 completed questionnaires represent the most comprehensive study of its kind ever done in South Africa and provide us with a solid basis for the development of strategies to improve knowledge utilisation[1].

The two key 'dependent' variables of the survey were (1) reported utilisation of research (findings) and (2) the extent to which the expected outcomes of the research had been attained. In the former case, respondents were asked to indicate the extent to which their research had been recognised, implemented or utilised by the intended users or beneficiaries. The second question asked respondents to indicate the expected outcome or value of their research, as well as the degree to which the outcome had been attained. We present the results on these two questions in Figure 3.1 and Table 3.4 respectively. Given the statistically significant differences between the main sectors of performance, the results in both cases have been cross-tabulated with the sector.

Figure 3.1 shows that more respondents working within the science council sector reported higher percentages of research utilisation than their counterparts in the university and technikon sectors. Across all sectors, 57% of respondents indicated that there had been some degree of implementation, recognition or utilisation of their research.

Figure 3.1: Utilisation of research by intended beneficiaries, per sector



[1] Given the survey design, sample size and sample realisation, we would estimate that the margin of error (at a 95% confidence level) on all reported percentages would range between 5 and 8 %.

Table 3.4: Expected value / outcome of the research, per sector

Expected value / outcome	All sectors	Science council	University	Technikon
Advancement in knowledge	70	66	72	63
Development of skills and competencies	33	34	32	36
Training of students	30	11	39	34
Solving immediate technical/ applied problems	24	39	18	20
Influenced decision-makers	23	24	21	19
Solving environmental or social problems	21	25	19	20
Change in behaviour/ attitudes/ values	19	12	21	28
Development of new technology	14	23	10	15
Solving of theoretical problems	13	9	16	8
Improved product or technical design	8	12	7	7
Change legislation	4	5	4	2
Entrance into new markets	3	7	2	3
Engineered a prototype	3	5	2	3

In a follow-up question, for each outcome or value selected, the project leader indicated the extent to which he/she believed that the outcome has been successfully attained. Three options were given: highly successful, successful to some extent, and not successful at all (Table 3.5).

Table 3.5: Successful attainment of research outcome

Expected value / outcome	Successful (%)				Number of projects
	Highly	To some extent	Not at all	No response	
Advancement or improvement in knowledge	68	30	0	2	1253
Training of students	67	31	1	2	536
Engineered a prototype	61	35	0	6	55
Development of skills and competencies	57	40	2	2	595
Development of new technology	54	43	2	2	260
Improved product or technical design	53	41	3	2	150
Solving immediate technical /applied problems	53	45	1	1	438
Solving of theoretical problems	42	53	1	4	236
Entrance into new markets	37	53	8	2	62
Influenced decision-makers	28	59	11	2	391
Solving environmental or social problems	28	65	5	2	382
Change in behaviour/ attitudes/ values	27	65	6	2	338
Change legislation	18	58	19	4	72

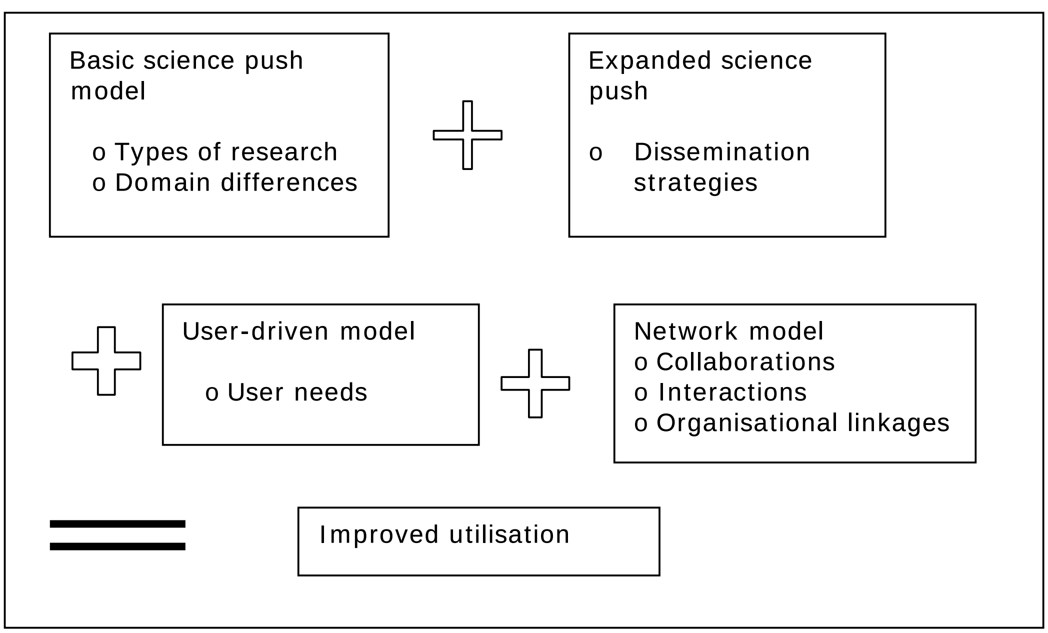
Taken together, the results of Tables 3.4 and 3.5 reveal some interesting patterns. The estimates of expected outcomes (Table 3.4) vary greatly from high proportions of outcomes associated with scientific utility (advancement of knowledge) to very low percentages of economic utility (engineering new prototypes and entering new markets). This large range of expected outcomes reflects the perceived risk and uncertainty involved as one moves down the research and innovation chain. The more complex the process of research uptake becomes, the less certain the scientist can be about possible applications and commercially viable end-products.

At the same time, the results in Table 3.5 show an interesting split between the expected successful attainment of different knowledge products. Respondents remain positive about the achievement of scientific outcomes (advancement of knowledge) but are much more sceptical about the attainment of most of the socio-political outcomes (changing legislation/changing behaviour/solving social problems). Interestingly, there is greater optimism about the successful attainment of technological outcomes (engineering new prototypes, developing new technologies and improving products and designs). Although small numbers of respondents listed technological innovations and commercial applications as the expected outcomes of their research, they are more positive about attaining such outcomes. Conversely, although socio-political outcomes were listed as expected outcomes in a significant number of cases, the project leaders were more sceptical about successfully attaining these outcomes.

3.2 Correlates of effective research utilisation

Although the survey was not aimed at testing a specific model of research utilisation, the data allow us to look more closely at the relationship between various factors known to be correlated with effective utilisation. We have grouped these factors together according to the three models discussed in Chapter 2 (cf. Figure 3.2).

Figure 3.2: Factors correlated with effective research utilisation

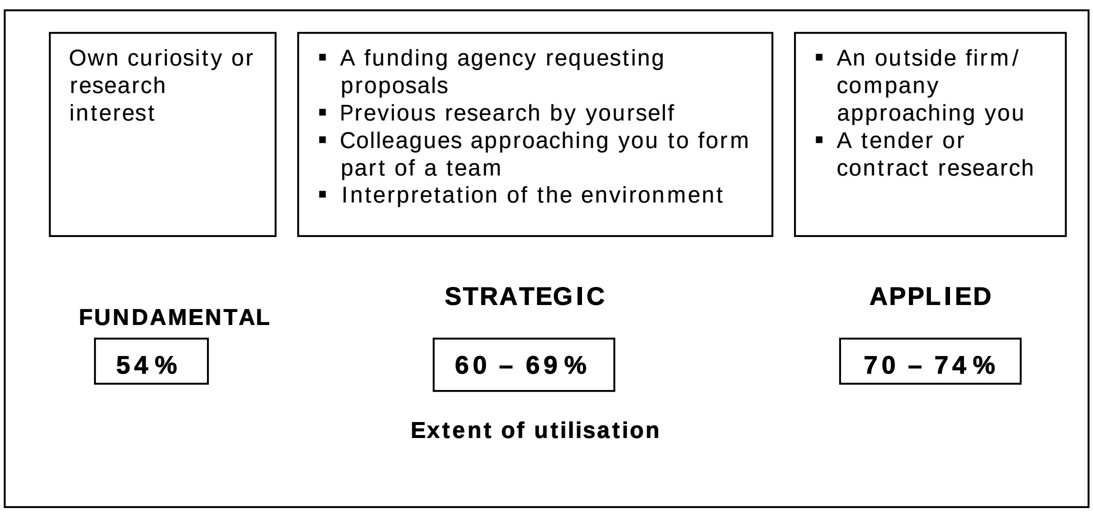


3.2.1 Types of research (triggers of research)

'Type of research' is often defined (following Frascati) in terms of the distinction between fundamental, strategic and applied research activities. We believe that this threefold distinction does not always capture the complexity of types of R&D, especially when the focus is on the utilisation of research. For this reason, we asked respondents to indicate the main 'trigger' of the research, or main motive behind the research project. We believe that the focus on the motive or rationale behind the research project is as good an indicator of the nature of the research conducted (if not better). Figure 3.3 below shows how our classification can be mapped onto the traditional categories of fundamental, strategic and applied research. We have, included in the diagramme the reported utilisation for each category.

As one would expect, higher reported utilisation is related to those 'triggers' of research that concern commissions from outside firms or companies and contracted research. The four 'triggers' that we would classify as denoting 'strategic research' all have somewhat lower levels of reported utilisation. Finally, at the other end of the scale, we find that research that is driven largely by curiosity has the lowest levels of reported utilisation. It is worth pointing out, however, that of the projects said to have been driven by the respondents' own curiosity or research interest, 54% were reported to have been recognised or utilised. This somewhat counter-intuitive result can be explained by two factors: firstly, research is usually not conducted for only one reason – the 'own interest' trigger - does not rule out other research motives; secondly, many respondents would likely think in terms of a broader notion of utilisation (including scientific utility) when reporting on their results.

Figure 3.3: The relationship between 'triggers' of R&D and types of R&D



3.2.2 Research utilisation within different scientific domains

Previous studies have consistently shown that utilisation is strongly correlated with the scientific domain or discipline. Again, this should not be surprising, given that scientific disciplines have different histories, different theoretical and philosophical cores, as well as relating differently to their objects of application. Some disciplines have a longer history of theoretical development and articulation (physics, chemistry, psychology, sociology); other disciplines have traditionally responded to specific occupational or professional demands (engineering, agriculture, social work, law). Table 3.6 summarises the range from high reported utilisation (nearly 70%) for the agricultural sciences to just above 50% for the mathematical sciences. Cross-tabulations with motives of research show that these results can partly be explained by the fact that the scientific domains that reported lower expected utilisation (mathematics and social sciences) are also more highly correlated with more fundamental research interests (e.g. own curiosity).

Table 3.6: Effective research utilisation and research domain

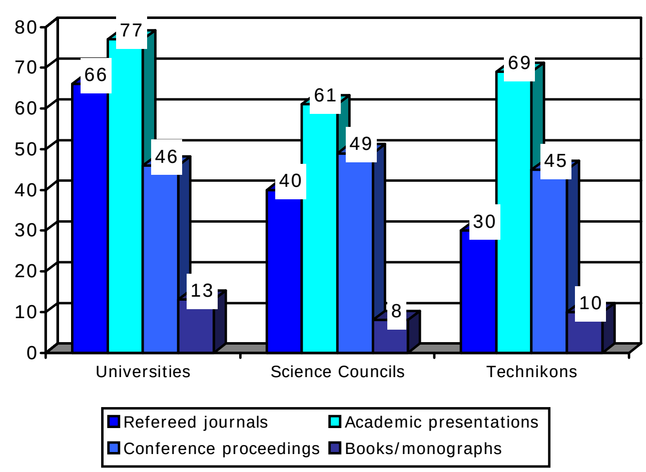
Broad research domain	Did the intended beneficiaries recognise / utilise / implement the research as planned?				Number of projects
	Yes, to some extent	Yes, to little extent	No, not at all	Don't know	
Agricultural sciences	69	13	6	12	326
Environmental sciences	66	13	8	13	278
Biological sciences	65	16	6	13	297
Engineering sciences	65	12	12	11	213
Earth sciences	64	20	5	11	132
Medical sciences: clinical	64	9	5	22	64
Physical sciences	63	8	8	21	76
Applied science and technologies	61	16	12	11	340
Information and communication technologies	60	16	12	12	141
Medical sciences: basic	59	15	6	20	92
Chemical sciences	59	13	12	16	123
Health sciences	57	17	8	18	297
Marine sciences	57	22	8	13	37
Material sciences	56	19	12	13	75
Social sciences	53	22	8	17	433
Economic and management sciences	53	21	7	19	243
Arts and humanities	53	19	6	22	333
Mathematical sciences	52	17	6	25	86

3.2.3 Dissemination strategies and organisational interests

Scientists have traditionally disseminated their research findings through a number of 'academic' channels: peer reviewed journals, chapters in books or anthologies, through presentations at academic conferences and in proceedings. These 'academic' modes of dissemination have increasingly – under the demands of users in government, industry and civil society – been augmented by non-academic forms of dissemination: such as presentations to non-academic audiences, publications of technical manuals and contract reports, and submissions to expert panels and so on. These two 'categories' of dissemination modes correlate strongly with the underlying values of the science push model of utilisation (driven by concerns of scientific utility and the advancement of scholarship) and the user-driven model of utilisation (driven by economic and socio-political utility and the application of research findings). The network model of utilisation forces us to focus also on other forms of dissemination, such as personal interactions, exchange of staff (transfer of embodied knowledge), regular briefings and workshops between producers and users of knowledge. It also requires that one look at the role of new organisational forms (such as technology transfer offices, spi-off companies, science parks and technology incubators) which have developed over the past 20 – 30 years to facilitate knowledge utilisation.

Dissemination strategies are not implemented outside institutional or organisational contexts, however (see Chapter 2.2). The organisational interests (even demands) for dissemination differ significantly, depending on the identity of the main R&D stakeholders. In the South African context, this is clearly illustrated by the traditional missions of the universities, technikons and science councils. Universities have traditionally been viewed as the cradles of basic fundamental science, with the advancement of knowledge as the aim. Technikons have been regarded as sites of applied research and technology development, with close links with industry. Science councils – at least in South Africa – were seen as national assets, undertaking strategic and applied research in support of national goals.

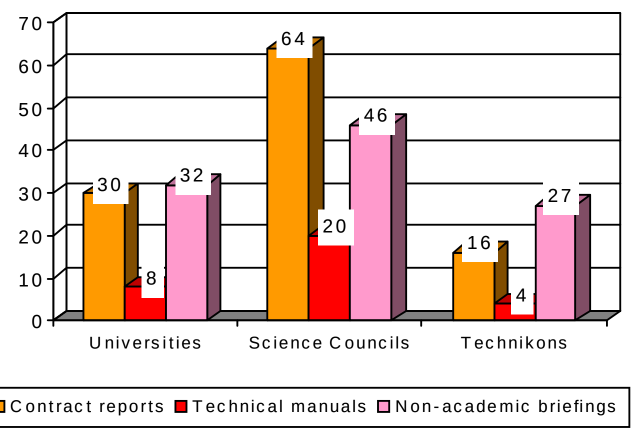
Figure 3.4: Academic modes of dissemination



The survey results produced a number of noteworthy findings. Firstly, dissemination modes are indeed strongly correlated with institutional missions and interests. Researchers at universities and (to a lesser extent) technikons still tend to utilise more academic forms of dissemination (peer-reviewed journal articles, books, monographs and presentations to academic audiences) to spread their research findings, in comparison with their colleagues in the science councils (Figure 3.4). Conversely, researchers in the science councils utilise more 'non-academic' modes of dissemination, such as contract reports, technical manuals and presentations to non-academic audiences (Figure 3.5).

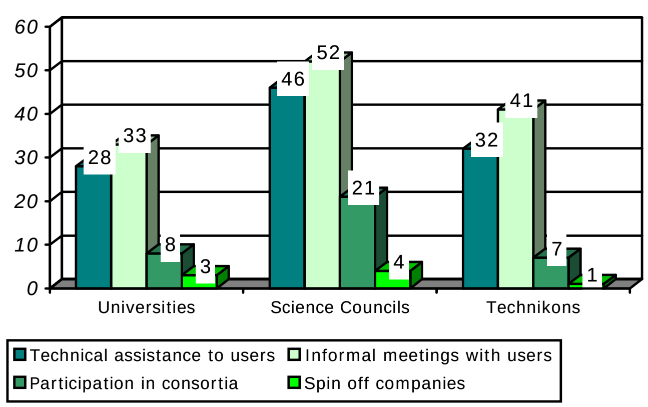
Secondly, although modes of dissemination correlate with institutional differences there are significant overlaps and blurring of boundaries. Significant proportions of academics at universities also produce contract reports and disseminate their results to non-academic audiences. Similarly, many researchers at science councils continue to disseminate their results through peer-reviewed journals and academic conference presentations, and researchers in all institutions disseminate their results through conferences proceedings.

Figure 3.5: User-driven dissemination



A third, and very interesting result, concerns the use of modes of dissemination other than traditional academic and non-academic channels. The questionnaire included a range of questions to measure the extent to which researchers utilise forms of interactions (meetings with users/consultations) and newer organisational structures (technology transfer offices, spin off companies). These modes of dissemination and interaction are good examples of networking in practice and are good indicators of whether and how researchers are spreading their research results through personal linkages, collaborative associations and other forms of networked communications. The results show that large numbers of researchers in all institutions utilise these 'new' modes of dissemination (Figure 3.6).

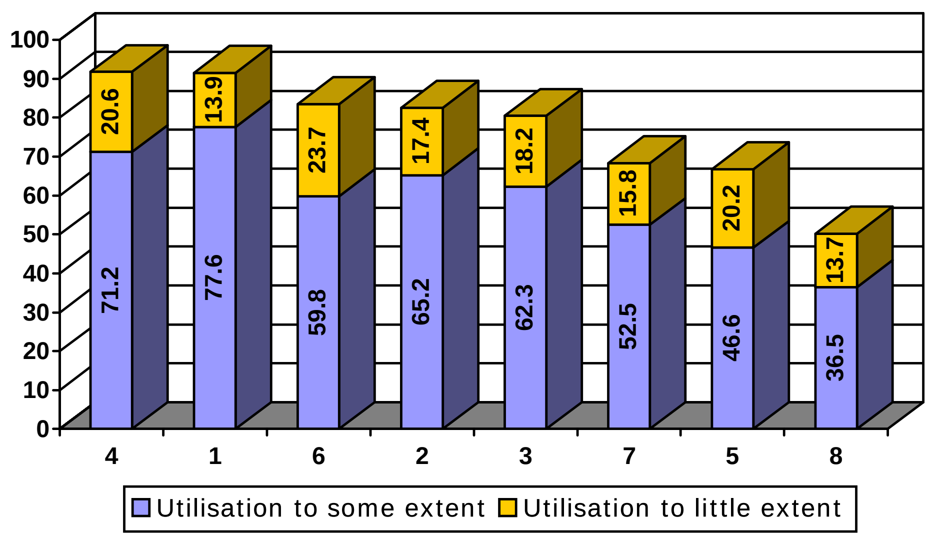
Figure 3.6: Network modes of dissemination



In order to establish how modes of dissemination and networking structures are related to reported utilisation of research, three clusters of projects were created. We have labelled these clusters 'academic-driven', 'user-driven' and 'network-driven' modes of dissemination. In each of the clusters, a project was categorised as 'above average' or 'below average', depending on how many forms of dissemination were reported to have been utilised. In this way, each project was assigned to one of eight categories. Projects that scored high on all forms of dissemination (in other words, according to the respondent, the findings of the project were disseminated using many, if not most, of the available channels) were assigned to category 1 (Figure 3.7 below). Conversely, where very few modes of dissemination were used, the project was assigned to category 8.

Cross-tabulating these new categories of dissemination modes with reported utilisation (using both 'utilisation to some extent' and 'utilisation to a little extent') shows that high levels of utilisation are strongly correlated with the application of multiple modes of dissemination. This is perhaps stating the obvious. The more a researcher disseminates his/her findings, the better the chances for utilisation. What is more interesting is that highest reported utilisation is more clearly correlated with network modes of dissemination. This is best demonstrated when comparing the extreme ends of the chart: above average dissemination on all forms of dissemination, or at least using user-driven and network modes led to highest reported utilisation (more than 90%). Below average dissemination on all forms of dissemination led to lowest reported utilisation (50%).

Figure 3.7: Modes of dissemination and reported utilisation of research

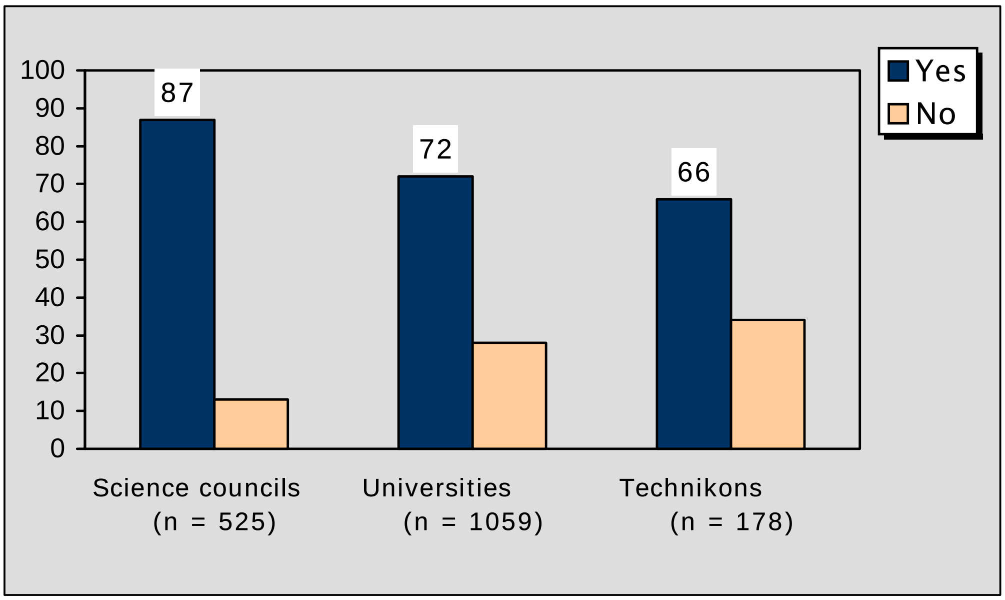


Codes:
1 = Above average on all three modes of dissemination
2 = Above average on academic-driven and user-driven only
3 = Above average on academic-driven and network-driven only
4 = Above average on user-driven and network-driven only
5 = Above average on academic-driven only
6 = Above average on user-driven only
7 = Above average on network-driven only
8 = Below average on all three modes of dissemination

3.2.4 Research utilisation and collaboration

The network model of research utilisation predicts that utilisation will correlate strongly with the degree or intensity of collaboration among researchers. Respondents were first asked to indicate whether or not the project leaders collaborated with others on the project. Overall, 76% of all project leaders reported some form of collaboration, with the highest incidence of collaborative activities (87%) reported for the science council sector (Figure 3.8). In a follow-up question, respondents were asked to indicate the sector with which they collaborated most often (Table 3.7).

Figure 3.8: Incidence of research collaboration, per sector



According to Table 3.7 the collaborators are mostly fellow academics and scholars, although this is less true for technikons. Researchers at science councils show the greatest variation in collaboration, as they record the highest incidences of collaboration with industry/business, government, other science councils and NGOs.

Table 3.7: Sector of collaboration, per institutional classification

Collaborated with ...	All sectors		Science councils		Universities		Technikons	
	N	%	N	%	N	%	N	%
Academics/ scholars	1076	60	300	56	685	63	91	50
Industry/ business	422	23	215	40	167	15	40	22
Government	284	16	144	27	115	11	25	14
Science council(s)	231	13	179	33	46	4	6	3
NGOs	160	9	70	13	75	7	15	8

Using a multivariate technique (CHAID) to establish which of a number of variables (scientific domain, size of project, type of research, institutional sector) best explained differences in research utilisation, it was found that the most significant predictor was whether collaboration occurred or not. In order to assess how different predictor variables are related to reported effective utilisation, we conducted separate CHAID-analyses for the humanities and social sciences, the engineering and applied technological sciences, and the agricultural and environmental sciences separately. The results of the three CHAID-analyses showed quite marked differences among the three domains. In the case of the social sciences and humanities, the most important predictor to emerge was whether collaboration occurred or not, followed by differences in the research experience of the project leader (Table 3.8). Whether collaboration took place or not was the only significant correlate in the case of the engineering and applied technological sciences. Where collaboration was reported, effective utilisation was reported for 66% of the projects; where there no collaboration was reported, the percentage of reported utilisation of research findings dropped to 36%.

Table 3.8: Predictors of effective utilisation in the case of the social sciences and humanities

Predictor	% effective utilisation
Collaboration with other researchers and above average research experience of project leader	69%
Collaboration with other researchers and below average research experience of project leader	53%
No collaboration with other researchers/projects	39%

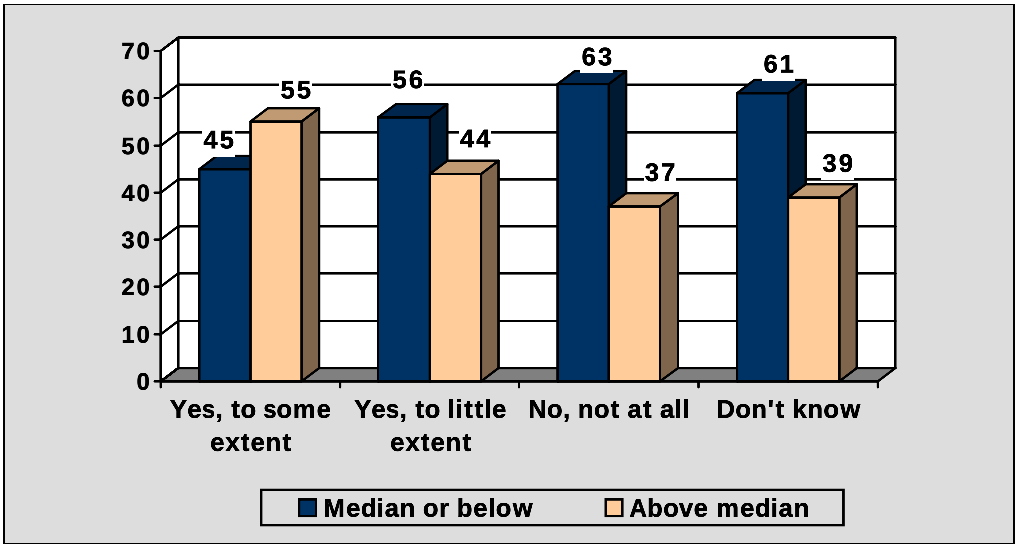
As far as the agricultural and environmental sciences are concerned, the institutional sector (science councils vs. higher education sector) proved to be the only significant correlate. Research projects in the science council sector (predominantly within the Agricultural Research Council) were reported to be effectively utilised in 71% of cases; the percentage for the universities and technikons was much lower at 59%.

These findings are important because they again show that institutional context is an important factor in understanding the dynamics that underpin the effective utilisation of research findings. The fact that research undertaken in the science council sector (as graphically illustrated by the example of the agricultural sciences) generally reports higher utilisation, is yet another indication that the nature of R&D conducted – which is also correlated with science domain – is a strong predictor of whether utilisation takes place or not. Despite the increasing blurring of boundaries between the science councils and higher education institutions, it is still fair to say that more applied and applications-driven research occurs within the science councils. In terms of the Bozeman model: the demand environment that influences R&D within science councils places a higher premium on applied and commissioned research that will produce results. Conversely, although there has been a noticeable shift toward applied and Mode 2 forms of research at South African universities and technikons over the past decade, it is still the case that basic fundamental and curiosity-driven research is encountered at these institutions than anywhere else.

3.2.5 Research utilisation and project resources

The multivariate analyses referred to above point to two additional factors that are positively correlated with higher reported research utilisation: the experience of the project leader and the available project funds. The relationship between years of experience as a researcher and research utilisation is clearly illustrated in Figure 3.9. Where the project leader has above average experience, reported utilisation occurred, to some extent, in 55% of the projects. Conversely, where the experience of the researcher is below average, reported utilisation occurred in only 45% of the projects.

Figure 3.9: Cross-tabulation between research utilisation and years of research experience



Size of project funding also emerged as a strong determinant of research utilisation, as shown in Table 3.9. The general trend is that the higher the category of funding, the greater the possibility that the research will be utilised. Similarly, smaller categories of funding are associated with greater uncertainty about the potential utilisation of the research.

Table 3.9: Cross-tabulation: Research utilisation and project funding

Funding	Did the intended beneficiaries recognise / utilise / implement the research as planned?				Number of projects
	Yes, to some extent	Yes, to little extent	No, not at all	Don't know	
Higher education					
Less than R50 000	44	21	9	26	657
R50 000 – R249 000	64	13	7	16	276
R250 000 or more	75	13	5	7	211
Science council sector					
Less than R250 000	58	16	8	18	216
R250 000 – R999 000	65	19	9	7	172
R1 000 000 or more	71	15	7	7	123

Research experience and project funds are project resources. More funding allows the project leader to do more; more experienced project leaders have access to more intellectual capital (in the form of established networks and linkages over time). Although these factors could be interpreted within a science push model of utilisation (these being resources that strengthen knowledge production), it is not far-fetched to understand how additional project resources could also be understood within a network model of utilisation. Additional resources (funding and experience) allow the project to engage more with other researchers (collaboration) and also to disseminate findings through multiple modes of dissemination (networked dissemination).

3.3 Industry interviews

Various topics were covered during the interviews conducted with research and technology managers, including the value of collaboration within industrial R&D, recent trends towards outsourcing research services, and the changing nature of the demand environment in which companies operate. For the purposes of this report, we focus on those factors identified by interviewees as either limiting or enhancing knowledge utilisation (especially technology transfer).

Box 3.1: Factors limiting technology transfer

- Lack of appropriate skills
- Inadequate finances
- Lack of equipment
- Insufficient knowledge
- Secrecy around IP
- Inadequate government support
- Conflicting cultures
- Limited or stagnating markets

3.3.1 Factors inhibiting technology transfer

a. The lack of appropriately skilled human resources in the country.

By far the biggest problem reported by respondents with regard to R&D in general is the shortage of skilled human resources in South Africa. For many companies, the brain drain in South Africa is contributing to and exacerbating the skills shortages. Others attributed the lack of skills to what they perceive as the declining R&D capacity in higher education institutions (HEIs) and science councils, or low participation and throughput rates amongst school and higher education students, especially in mathematics and science. For most, the greatest loss is the invaluable tacit knowledge that is acquired only through years of experience.

> *R&D is not about buildings and it is not about specific locations, it is about people and accessing people. My main worries are the overall available skills level in SA to service South African industry generally, and at the quality of the average graduate coming out of university..*
>
> (Mining: Amplats Research Centre)

Brain drain: Many respondents reported that they had lost skills through migration, by staff being poached by other companies locally or abroad, leaving the industry and moving into a new occupation altogether, or leaving to set up their own businesses. Part of the difficulty of retaining staff is that companies are often unable to compete with the attractive salary packages.

> *We do battle to find very strong, capable chemists, and I think in our case, it is about strong chemists who not just do research in the laboratory, but who have the ability to apply, application of, technology in a multinational type culture, that is why we get so limited.*
>
> (Chemicals: Unilever)

Inadequate skills replacement: Replacing lost skills is not always simple: there are insufficient numbers of graduates, especially those with qualifications in mathematics and science, entering certain industries. In addition, it can take a long time to train new employees, and for them to gain experience to the required level. The high cost of recruiting much-needed skills from abroad is sometimes prohibitive

b. Declining or inadequate capacity in universities and science councils*:* A number of respondents indicated that they have major concerns about what they perceive to be a deterioration in the capacity of universities and science councils in South Africa to support company R&D. In part, this is attributed to the decline in funding and available resources in these institutions. Mostly, however, there is concern about the ageing and shrinking scientific workforce in the public sector., The ageing of the scientific workforce can result, among other things, in what one respondent referred to as "technological lock-in"; in other words, when older academics and scientists get stuck in a particular way of thinking about technology. At the same time, the lack of young blood coming into the system means that there is a dearth of new, fresh and innovative ideas.

> *I am absolutely convinced in my working with the universities that in ten years time there will be no capacity for us. In the universities, I see a bleak future for them as a partner, and they don't seem to have - they might intellectually claim that that is a problem - but they don't seem to emotionally have accepted that in terms of a change in practice – that is how to deal with it. Similarly in our own situation, I also see the difficulty in the next generation researcher. We've got extremely competent PhDs and Master degreed people who have ten years of experience, but we've got very little influx of freshly graduated MDs who seem to have the capabilities to replace their more experienced colleagues.*
>
> (Mining: De Beers (1))

c. The lack of certain equipment and facilities locally. Respondents reported that equipment is often not up-to-date or cutting edge. In addition, certain materials, equipment and facilities are simply not available locally and, as a result, companies are compelled to seek these abroad.

> *The amount of money that is put into research, and I would say industrial research, has to be linked to the probability of getting something back for that investment, and in South Africa, being a relatively limited market, I think there are fewer opportunities to invest heavily and get heavy returns. The international companies, multinational companies, of which there are very few in South Africa, but SASOL would be a good example, I think they still invest heavily in research ... They have enough critical mass to see the return on that, coming not only in South Africa but also in the world. Now for us to invest heavily when we have the option of licences or technology agreements with bigger companies doesn't really make too much sense.*
>
> (Chemicals: AECI Specialty Chemicals)

d. Inadequate sources of knowledge or information. Company R&D is sometimes limited by the lack of information, prior research and/or particular specialist knowledge in South Africa. In part, this has to do with human resource capacity and the status of research in a particular field. In addition, journals are often considered to be out-of-date, to provide irrelevant information, or they are too expensive to purchase. The unavailability of research or technical information in the country also causes companies to keep some, if not all, their intellectual property secret from the competitors.

e. Secrecy around intellectual property. The results of company R&D are usually disseminated only to a limited number of recipients or users, and often only in limited ways, unlike the the case with publicly funded research outputs, to which there is (apparently) open access. Moreover, companies adopt various strategies to protect their intellectual property, to guard their secrets from the competition (e.g. through patents or non-disclosure agreements). In many ways, this makes good business sense, but the secrecy has a number of somewhat paradoxical implications. One is that it limits the possibilities of outsourcing and collaboration, since companies are likely to be highly selective about whom they reveal their secrets to. Another is that it decreases the availability of the very sources of information and know-how that companies rely on to inform their own R&D agenda and activities. It can also limit the advantages gained from sharing information, for example, in industry forums. In this sense, intellectual property is a major issue in the broader R&D process, where competition with other companies gives rise to secrecy rather than open sharing.

> *There are networks, but the competitive nature of the industry doesn't make a pool database of knowledge a practical reality. I think this is another one of the debates we've had over many years and with respect, with many academics who have tried to convince us that we should put all our cards on the table and we all share it and all live happily ever after. This is not the reality of business. If we have an edge over one of our competitors, we keep it within our deepest pockets and make sure that we retain the edge.*
>
> (Electronic hardware, systems & software: Grintek (2))

f. Inadequate government incentives, resources and support. Except for funding mechanisms such as THRIP and the Innovation Fund, respondents reported that companies are offered no incentives by government to pursue R&D. In addition, for some, the support offered by government left a lot to be desired, particularly the bureaucratic nature of the process which can result in the company missing a window of opportunity. For others, the criteria and conditions associated with government funding are problematic. And, funding programmes such as THRIP require collaboration between HEIs and industry. This can raise intellectual property issues which might make a company reluctant to participate.

> *You know the one thing that I feel quite strongly about is that although there is some government support as far as, let's call it the research and development component, in our view that sometimes that represents only a small percentage of the cost involved in getting a technology based product into international markets. And by the time your development funding stops, maybe you've actually spent 25% of what you need to really launch an internationally successful product. ... So, I think there needs to be more emphasis on taking products to market and a national effort to help bright ideas actually succeed in the world market rather than just the generation of bright ideas.*
>
> (Electronic hardware, systems & software: Tellumat)

g. The conflicting agendas of industry and academia in the context of R&D collaboration and outsourcing. In current times, there are many compelling reasons for HEIs and industry to collaborate around R&D. Within the higher education sector internationally, collaboration is increasingly becoming an imperative for the survival of HEIs. More than ever before, HEIs are dependent on external funding and contracts for research, as their own budgets shrink. At the same time, they are under pressure from governments to develop partnerships with, and be more responsive to the needs of business and industry. This is reflected in the emphasis on programmes in science and technology, as well as research collaboration and contracts.

These trends are increasingly evident in South Africa, as our own universities and technikons are compelled to seek partners with whom to collaborate. These collaborative relationships are not without their challenges, however. A recent study by Wickham (2002), for instance, which investigated industry partners' experiences of partnerships with HEIs, revealed that a critical issue facing HE-industry partnerships is the apparently conflicting agendas of the two. Respondents in our own industry interviews also highlighted these kinds of problems. They reported that the 'cultural differences' between industry and academia often pose a challenge in terms of R&D outsourcing and collaboration. For instance, respondents complained that:

- Academics are unable or unwilling to take their research to a practical application level
- Academics do not understand or appreciate the way in which business operates, and
- The different timeframes, priorities, standards and commitments (e.g. to postgraduate students) within HEIs often conflicted with the company's own agenda.

h. Limited or stagnating local markets. Limited or stagnating local markets can reduce the demand for particular R&D activities, or they can impact on the company's success in getting their products to market.

3.3.2 Factors that promote R&D and technology transfer

Respondents reported a range of factors that make a positive contribution to company R&D. Some of these factors relate directly to the circumstances of individual companies and the approaches they adopt. For instance, some companies are simply well-endowed in terms of finances, human resources and a solid knowledgebase. Others attribute their success to a positive attitude towards innovation and R&D within the company, and incentives for their own staff to develop their skills in conducting R&D and implementing or applying the results. Other positive factors were more indirectly related to characteristics of the South African context that were particularly advantageous in terms of R&D.

Box 3.2: Factors that promote technology transfer

- Adequate financial and human resources
- Companies geared to innovation
- Good HR management
- Regular evaluation of R&D outcomes
- SA's competititve advantage

a. Adequate financial, human and knowledge resources. Some respondents indicated that they are adequately equipped in terms of financial and human resources, and access to knowledge and information. The government's contribution to company R&D, via funding mechanisms such as THRIP, was also acknowledged and appreciated.

b. Companies geared towards innovation and R&D. Certain companies are entirely focused on change and innovation within their business operations which means that they respond proactively to the innovation imperative, and offer incentives to their staff to be as innovative as possible. It also means that management values the role of R&D in the company, and provides adequate funding and strong support to the R&D function. One company in particular appears to have taken great strides towards 'institutionalising' R&D and innovation by, amongst others, developing an intranet system which facilitates and integrates communication and the sharing of new ideas and findings around R&D within the company.

> *I think what is very important to know is that every year I go to management board and I have to say to them, "Mr Chairman, I need so many million a year for next year", or the next five years. And what we normally get is, in principle, support for the five-year period, which I believe is absolutely crucial for the sustainability of any research organisation. There is no way that we can plan from one year to the next, because some of our projects last for five, six or seven years. If an organisation believes they are going to be competitively advantaged to technology and they have a one-year window frame, they are going to lose it. I think this is why it is so important that our technology roadmap highlights those issues and I believe the role of the technology roadmap is key and paramount in the way we do things.*
>
> (Services & infrastructure: Eskom)

c. Good human resources management. Some firms have been successful in implementing strategies to attract and retain key R&D staff, through incentives and opportunities for development and promotion.

d. Evaluating the outcomes of company R&D. One respondent spoke of the system of evaluating the outputs and outcomes of R&D activities in his company. The company evaluates their numerous R&D projects via customer feedback and a "return-rate on investment" (RRI) exercise. Clearly, this kind of evaluative exercise can play a significant role in ensuring that R&D is effectively utilised in the long run. It is also a way of demonstrating the real and potential value of R&D to the firm.

e The 'South African advantage'. While a number of respondents highlighted the disadvantages associated with conducting R&D in South Africa (e.g. the limited skills base or the lack of adequate funding), others indicated that these factors could in fact be viewed as advantages. In particular, respondents reported that South Africa is regarded as a *quality* but *inexpensive* site for R&D for companies abroad. In other words, skilled labour is comparatively cheap but, as a few respondents indicated, overseas companies find South Africans to be hard workers and, therefore, comparatively more productive. This is possibly easiest within multinational corporations since the necessary linkages are already there. This is an opportunity to be exploited: if local and overseas companies were to invest more in R&D in South Africa, this would generate additional funding and contracts, and help to build our R&D capacity in the future.

> *We have a huge cost advantage, so work done here is roughly 20% to 25% of doing work in the US or so. So, it makes a lot of sense to move more R&D to SA. Companies have tried this with other developing countries, like India, for example, but I think we have a specific niche in being able to provide the kind of customer communications and interfacing, which is on a parallel on what you would get in First World countries, but combined with a lot of costs as well.*
>
> (Electronic hardware, systems & software: Azisa)

Some companies have evidently been successful in overcoming the challenges surrounding company R&D in this country. Internally, companies have found ways to tap into and retain highly skilled staff, or to leverage adequate funding to successfully pursue R&D and ensure its effective utilisation. To a large extent, these measures are a function of a positive and proactive attitude towards

R&D and innovation. Externally, some companies have recognised that South Africa has a unique advantage which can be exploited: our 'competitive edge' internationally is rooted in the combination of so-called 'first' and 'third world' attributes, for example, top class infrastructure but cheap skilled labour and overheads. Certainly, if we encourage companies abroad to bring their R&D requirements to this country, this could amount to a considerable investment in R&D in South Africa. It could expand the skills and knowledge bases in the country, and create important links with companies and organisations abroad. This is an opportunity to put South Africa on the global R&D map!

3.3.3 Summary

We have summarised the factors that impact on company R&D and, in particular, those that lead to results not being used at all. We have attempted to match each of these factors to the particular stage in the process of innovation in which they are likely to occur (Table 3.10).

Table 3.10: Factors that limit utilisation

Stage in the research and in-novation process	Limiting factors
Setting the R&D agenda	• Inadequate information can lead to the poor conceptualisation of an R&D project, which later might result in a product that is inappropriate and which cannot be used • A lack of proper consultation with intended users at the start can lead to problems with utilisation later on (cf the fit between purpose and intended user and users)
R&D activities	• The quality and ultimate success of R&D might be compromised by a lack of skills, equipment, information or funding, or by political pressure • Longer-term, basic research is under greater threat than short-term, application-driven R&D of not being utilised, or pursued in the first place
Dissemination	• Dissemination of R&D outputs is usually restricted (e.g. patents, licenses, keeping it internal) which reduces the amount of information or knowledge available to South African industry as a whole • Wider dissemination (e.g. in journals or at conferences) is also limited and is usually too general or out-of-date to be of much immediate use
Commercialisation	• The more theoretical orientation of many academics and public sector scientists can lead to results which are too impractical to properly commercialise • A lack of funds can result in the product not being commercialised (note that government funding does not cover commercialisation)
Stage in the research and in-novation process	**Limiting factors**
Technology transfer	• When the tacit knowledge associated with the R&D process and outputs is not transferred, this can result in limited or no utilisation on the part of users (cf the absorptive capacity of firms) • In cases where technology transfer is institutionalised, e.g. in agricultural extension, a lack of resources, both human and financial, can result in very limited utilisation or implementation. • When users are sceptical about the value of the change suggested by the R&D, do not have the skills to apply R&D outputs in their own contexts, or who are simply resistant to change, they are likely to not use the R&D at all.
Product development	• The outputs of R&D will not be effectively utilised if there is no market for product, or the product turns out to not be competitive. To some extent, this could be because the company did not do its homework properly! • R&D activities might not be realised if a competitor gets to the market first.
Evaluating the outcomes of R&D	• Companies would do well to implement a system of ongoing monitoring and evaluation of the process, outcomes and utilisation of R&D.

3.4 Case studies

Twelve case studies were studied in detail. These were selected from an initial list of 20 to describe a set of publicly funded research projects from a range of research types.

The major lessons learnt from the twelve in-depth case studies are organised around the following thirteen themes:

- Research project leadership
- Research teams and personnel issues
- Funding
- Project review and monitoring
- General project management issues
- Project duration and timing
- Intellectual property rights and agreements
- Modes of research
- Research foci
- Institutional issues
- Users and stakeholders
- Networks
- Dissemination and communication of findings

Research project leadership

- All major research projects require strong leadership and a commitment to delivery.
- Research leaders must be well networked with both users of research and other local and international researchers and research institutions.
- Research leaders need well-developed communication skills, including the strategic use of various media for different purposes (for example, policy briefs or useful technical articles for industry).
- Project leaders need to be flexible in situations of crisis, such as when research-funding sources dry up, in which case other potential funding agencies will have to be approached with suitable motivations.

Research teams and personnel issues

- Having the right mix of senior researchers and postgraduate students, as well as connections with national and international research partners, creates a dynamic environment for the dissemination and utilisation of research findings.
- The research team must be sufficiently flexible to respond to new user needs.
- Common commitment among members of the research team is essential.
- The commitment of research leaders and teams to salvaging useful aspects even from projects that have gone wrong, rather than abandoning them, helps ensure that all projects yield some good.
- Research teams that engage with well-organised international research programmes find that they learn good research management practices from fulfilling such engagements.
- Setting clear goals aids the cohesion of the research team, which is an important ingredient for obtaining successful conclusions. Disagreements and lack of cordial relations have to be carefully managed.

Review and monitoring processes

- A regular, properly managed and accountable external review process helps keep projects on track.
- Setting targets for the number of high quality research articles published encourages researchers to publish and be recognised as experts in their field.
- Well developed and correctly used reporting structures are necessary for monitoring progress and outputs.

General project management issues

- Progressive management and reporting structures and processes are conducive to better working relations and productivity.
- The current legal framework may prevent certain research findings from being implemented (for example, the products of biotechnology research). Project results must be well managed to ensure that they are used when the legal requirements can be met.
- Projects managed through international collaborative agreements (such as the European Union framework programmes) are more likely to be successful.
- If research agreements are entered into before all the technical challenges have been properly assessed, a seemingly clear objective may prove far more complex once research commences. Research leaders need to identify such problems early and engage stakeholders in finding solutions. Alternatively, researchers may be able to engage successfully with the problem to find innovative ways and funding streams to deal with more complex research than they initially envisaged.

Intellectual property rights and agreements

- Partners should reach agreement on intellectual property rights before entering into collaborative relationships. The process of negotiation should be carefully managed to ensure that there are no misunderstandings later, and the agreements reached should be recorded.

Project duration and timing

- Projects that will need a long term life span should be prioritised as such by funders and supporters. Shelving potentially long term projects after the initial findings become available is probably wasteful. It would be more sensible to keep such projects going at a lower intensity but at a relevant level so as to be in a position to resume the research more intensely when the time is right.

Modes of research

- A strong foundation of basic research is essential as the basis from which to develop relevant applied research.
- Accumulated skills and expertise in a research team should be actively engaged in more applied projects.

Research foci

- Research should be focused in the areas where the issues are clear and the needs of users are fairly precise.

- Researchers need to be resourceful in balancing their research portfolios in line with the needs of the sector in order to produce results that are relevant to stakeholders.

Institutional aspects

- The interest and support of the host institution is vital in seeing research projects through to successful conclusion. Without basic support and approval of this nature, research units and projects are unlikely to prosper.
- Research progresses faster if it is free of bureaucratic processes and external restrictions.
- If important research information, deemed vital for the success of the project, is difficult to obtain, research leaders must use the powers of their institution and stakeholders to obtain the information through appropriate agreements.

Users and stakeholders

- A well-established relationship with the senior users of research and a clear demand from such leaders helps ensure that delivery targets are met.
- It is vital to engage with the correct stakeholders and to maintain regular contact and exchange of information with them.
- Research teams need to be able to tailor their research results for different stakeholders as the project develops, since spin-offs or results not originally anticipated may be produced and prove to be of potential interest to other potentially suitable users.
- Research units with the best interests of their primary users at heart are usually the most successful at getting their research findings implemented. Conversely, research units without a clear view of potential users (unless engaged in pure basic research) are unlikely to have much success in the implementation of applied research.
- Managing relationships with major stakeholders requires careful attention, and it may be necessary to engage certain stakeholders very closely with the research process to ensure commitment and buy-in. Researchers might find that they need to put more effort into building relationships than they expected. Relationship building is a very important component of research management and cannot be left to chance or be entirely dependent on the research team’s perception of the high quality of the research it produces.
- Managing the triple helix of government, higher education and industry is vital for the successful implementation of the research findings of most large publicly funded research projects.

Networks

- Strong international research links should be maintained through mobility and exchange arrangements.
- Networking is facilitated by maintaining contact with past team members who remain interested in the field.

Dissemination and communication of findings

- The backing of the host institution is necessary for the dissemination and public communication of research findings.

Funding

- Funding lines and reporting requirements should always be agreed in advance of the commencement of the project.

- In cases where the scope or costs of projects are underestimated by research leaders and teams, funding and resource requirements should be renegotiated and agreed upon. If such issues are not addressed at the time that they arise, the result is likely to be tension with stakeholders and a lack of morale within the research team.
- Research leaders should ensure that achieving the anticipated research findings is within their capabilities when they apply for funding.
- In institutions that require certain financial returns from research projects, research leaders must ensure that all financial conditions are met before they agree to proceed with the research. Running out of funding on a committed research contract is a sign of poor management.

3.5 Provisional generalisations

Selected findings of three comprehensive empirical studies are reported in this chapter. These findings can be looked upon as first-order correlates of research utilisation within the context of the Bozeman conceptual model adapted for this project (see chapter 2) - time and space did not allow analyses of the full wealth of data gathered in these three studies. A close reading of this chapter, however, does allow for a number of provisional generalisations that have to be accounted for in the strategy development phase of the study. The following represent important coordinates for the strategy mapping exercise:

- Utilisation is a multidimensional concept requiring a spectrum of indicators
- The extent of self-reported utilisation is fairly extensive and also co-varied with science sector, with science councils performing better than the higher education sector, for example.
- The correlates of utilisation are reasonably constant across NSI sectors and institutions; the following were found to be some of the important ones that can potentially be managed:
  - Multiple dissemination strategies
  - Extent of collaboration
  - Institutional commitment to utilisation
  - Effective project management
  - Experience of the researcher
  - Size of funding

The empirical findings reported in this chapter are compatible with the basic predictions of the network model of utilisation outlined in Chapter Two. These findings clearly show that utilisation can in fact be improved if the appropriate environment and conditions are created in the national system of innovation – the subject of the next chapter.

CHAPTER 4

STRATEGIES FOR MORE EFFECTIVE RESEARCH UTILISATION

Chapter 1 of this report provides the broader context within which to locate policy discussions around research utilisation. The second chapter developed a conceptual framework for understanding the recent history of models and definitions of research utilisation Chapter 3 presents a summary of the empirical findings gained through the surveys, interviews and case studies. In this chapter, we present an integrated picture of the strategies developed and proposed to improve research utilisation.

Although the strategies described and discussed in this chapter were developed independently by three different agencies, using different methodologies and approaches, there are interesting similarities and complementarities. This is no doubt in large measure due to the fact that a common assumption underlies all three reports, viz. that the knowledge and innovation system is indeed a complex, interlinked network of mutual dependent actors, processes and events. Whether these 'networked interdependencies' are conceptualised in terms of a reworked Bozeman model (cf. Chapter 2), or a systems model, the basic premises and conclusions of the three studies are not fundamentally different. The fact that these approaches – and the subsequent formulation of strategic objectives - are congruent with the network model of utilisation presented in Chapter 2 has two positive results: (1) it provides a different kind of validation of the appropriateness of the network model, and (2) it makes the synthesis and integration of the proposals and recommendations of the three separate strategy reports much easier.

The chapter is divided into two main parts. We first present – in synoptic fashion - the methodology, key findings and recommendations of the three strategy partners separately. Each strategy group reworked its final report into a brief, summarised version which explains the methodology, the key strategies or strategic objectives, and the main recommendations. In the second part of the section, we have summarised the different strategies in Table 4.3. This table is an attempt both to reduce the large number of individual strategies proposed (more than 40),and to organise them according to more logical clusters (nine in all).

It is worth pointing out how the three strategy groups utilised three different methodologies in the development of their respective strategy recommendations:

- *Model building and simulation*: CyberKnowledge Systems (CKS) first designed and developed a conceptual model of a competitive innovation system, which formed the basis of a set of hypotheses. These hypotheses were subsequently tested through various simulations of the model which in turn informed the formulation of strategic objectives.
- *Delphi-type process*: Da Vinci Institute of Technology based its development of strategy on a process utilising the inputs of an expert panel. The panel was used both as a source of information and expertise about the system, as well as a facilitator of follow-up interviews with other key informants.
- *Stakeholder analysis and workshop:* Access Market International (AMI) conducted individual interviews with stakeholders in a range of sectors, after which a workshop was conducted with a representative group to formulate the strategic objectives.

4.1 CyberKnowledge Systems (CKS)

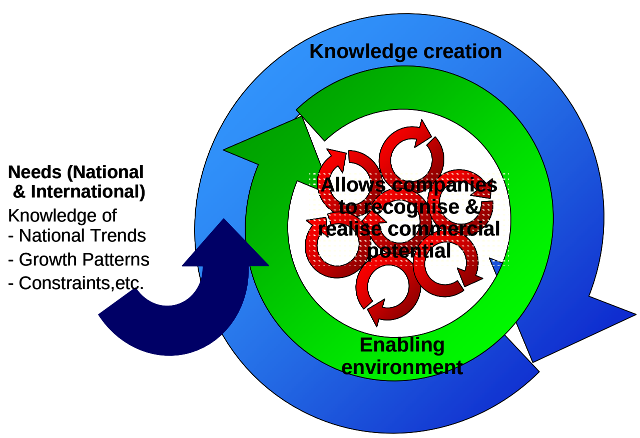
4.1.1 Methodology

CKS made use of building models to help clarify our understanding of research utilisation in the context of creating a more competitive innovation system for South Africa. Once a baseline hypothesis had been developed, it was modelled and refined in a process of reviewing or incorporating new information and testing the robustness of the conclusions. Finally, a strategic understanding was articulated, and a strategy developed, using the model to provide and test insights. The model was built using the *iThink* modelling methodology.

4.1.2 Model of a competitive innovation system

The model was built using the *iThink* modelling methodology (Richmond) and consisted of three cycles. The first is the knowledge-creation cycle and refers to the development of new and fundamental knowledge (e.g., theories, disciplines, etc.). The second cycle could be described as the establishment of a platform of enabling environments, including infrastructure, technology and skills, to ensure the production of knowledge-based products. The third cycle is the development of products (a few examples: mobile location based services – products can be physical products, complete units or components, processes or practices). Research utilisation occurs across all three cycles. The interaction between these cycles is illustrated in Figure 4.1.

Figure 4.1: High-level systemic view of a competitive innovation system



The process essentially starts by identifying the economic and social needs of the country through a process of examining national and international development trends and growth patterns and realistically establishing the constraints to the system. This process yields specific knowledge areas in which the country can be competitive, and critical knowledge gaps are identified. Knowledge is created within this framework, and once a certain threshold of knowledge has been established, it is possible to create enabling technology platforms (i.e. enabling environments), ensuring vital requirements for value creation are in place. It is then possible for more companies to develop products in the new technology/development area, realising the commercial potential of the knowledge area created originally. It is important to note that research utilisation happens within and across each of these cycles as an automatic coalescing of ideas into products or outputs.

4.1.3 Inferences from a simulation

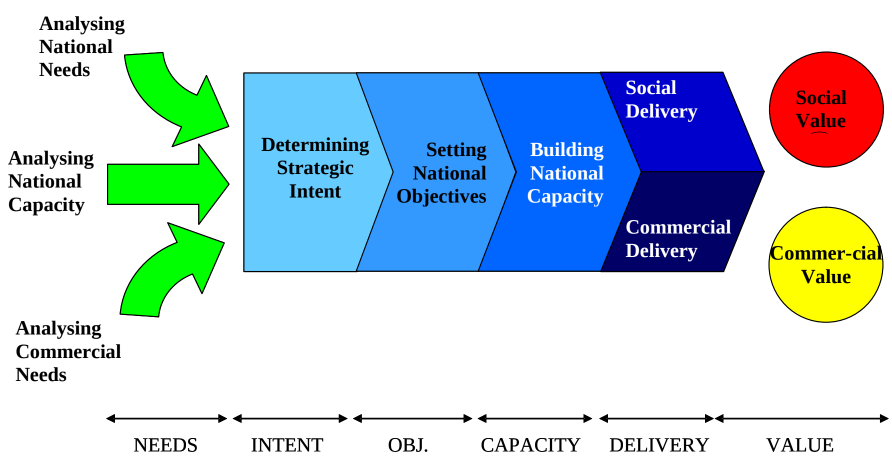
A simulation exercise that captures the high-level dynamics of the innovation process was undertaken to test the model. It clearly highlighted the following:

- Without a frame of reference within which these three cycles (knowledge, enablement and production) can operate (in other words, without identified and agreed needs), the knowledge and technology cycles continue in their own way, but the ultimate result is less commercial product development and little, if any, economic and social development. The right frame of reference (in terms of the national social and economic context) is therefore a critical factor in promoting research utilisation. The corollary to this is that research utilisation is an emerging phenomenon.
- Knowledge share and technology share (accessibility and absorption) have big knock-on effects - even fractional changes affect the ultimate commercial, economic and social outputs.
- Unduly emphasising the link between the market demand to the original identification of the need (by focussing on market-driven research only) diminishes the socio-economic development returns. It also introduces a slight perturbation into the socio-economic development cycle.
- Linking market demand with the initial needs identification significantly increases the number of products created.

4.1.4 Overview of key strategies

On the basis of the high-level systemic view of the innovation cycle depicted above and the dynamics between these cycles (observed in the simulation), it is clear that research utilisation is an example of what is described in complexity theory as an emergent phenomenon. This means that an environment that is conducive to or that encourages research utilisation (rather than regulating research utilisation) must be created. This environment is underpinned by a philosophy of value creation, guided by a shared purpose and understanding of the socio-economic and commercial requirements of South Africa**.** This requires clear articulation and alignment with the national value chain, as illustrated in Figure 4.2.

Figure 4.2: National value chain



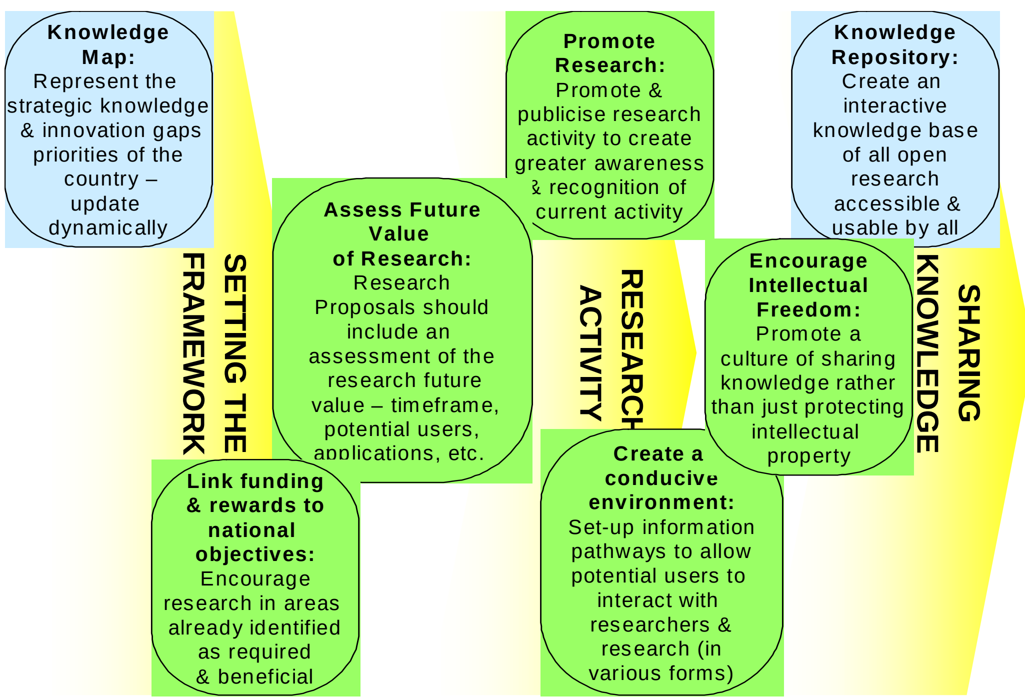
The dynamic behaviour of the simulated model indicates that for the national value chain to be effective, the following are required (from the role players in the national value chain):

- A shared understanding of the ultimate purpose
- An understanding of the national priorities and the implications thereof for their work
- An understanding of their value contribution (expected and actual)
- Sufficient support structures
- Sharing their work in a variety of forums to allow ongoing absorption and application – growth of knowledge and skill through sharing

From a systems dynamics perspective, the innovation model indicates that shared purpose is a fundamental driver in improving research utilisation.

In a nutshell, the strategy proposed for improving research utilisation is one, which understands that *the right framework* needs to be set within the innovation system to allow research utilisation to emerge. This framework needs to be clearly communicated and reinforced through the funding schemes. Changes in *research activity* that ought to be encouraged include the assessment of the future value of research and the active promotion of research activity. Then, very importantly, if research is to be used, it must be shared. This *knowledge sharing* must include having a knowledge repository of all open research, comprising various information channels or pathways through which researchers and potential users can interact. It is crucial, however, to foster a culture of sharing knowledge, and encouraging intellectual freedom necessary to optimising the exposure of potential users, thereby maximising the potential for research utilisation. In conclusion, the strategies and their overlaps are represented in Figure 4.3

Figure 4.3: Key recommendations



4.2 Da Vinci Institute of Technology

Da Vinci chose to utilise the experience and knowledge of people with a clear understanding of the research and commercialisation process to generate a strategy to increase the utilisation of research results. Individuals that understood government policies and processes enhanced this knowledge base. The essence of this approach to strategy development is characterised by using experts whose experience is backed up a body of evidence.

4.2.1 Methodology

The expert panel was assembled in Pretoria for five days on the basis of their individual expertise; they had an excellent grasp of the academic sector (3 panel members), industrial sector (2) and the science councils (2). In addition, the group had a strong background in the public sector and science-policy.

The panel received the outputs of the first two phases as pre-workshop reading as well as the following documents: Institutional Framework (a Da Vinci document); *South Africa's national R&D strategy*, *The Science and Technology White Paper*, and the Science Advisory Council (SAC) report on implementation of research findings (1990).

The expert panel also conducted eight interviews with leading members of government departments and industry

4.2.2 Strategic framework

The panel developed a conceptual framework of innovation dynamics on the basis of which key recommendations were formulated. The panel also proposed a framework for implementation.

A major criticism of most government-developed strategies is that their perspective is heavily biased towards government. Understanding the systemic location of 'research' within a value matrix is an essential component of attempting to address NACI's concern regarding the utilisation of research findings. A fresh conceptualisation of the innovation system dynamics was thus conceived to provide a framework for the strategy development

In this model, *supply* issues are identified and *demand* conditions explored, and there is an important interlinking *diffusion* domain between the two. The information flow between the domains is considered to operate in both directions in a constant process of feedback:

- The *supply* side is characterised by the R&D process, together with the specific inputs that would be required to make the system viable. The supply side process leads to knowledge generation in the form of research findings.
- The above findings are *diffused* through a number of processes or dissemination mechanisms, such as technology transfer and commercialisation. The diffusion outputs may be in the form of publications, patents, prototypes or other outputs.
- As regards *demand,* this knowledge is *driven* by differing market needs and utilised in differing ways. Note that the demand for knowledge is necessary to ensure that there is a well-developed feedback mechanism. The outputs that are generated by the various markets (academia, government and industry) range from citations to policy formulation, products and processes.

The overriding consideration emerging from this model is that it is the diffusion process that holds the key to unlocking the potential within the innovation system.

This process can most effectively be described by the term ‘research utilisation’, or ‘innovation’ in the narrower sense.

4.2.3 Recommendations

A large number of individual recommendations were developed. However, it was considered prudent to develop a framework for implementation in which the impact of the proposed strategy is greater than the sum of the individual interventions. It is within this paradigm that the creation of networks of innovation can be considered the crux of the strategy.

The concept of research collaboration is central to the proposed strategy of networks of innovation, the creation of which will enhance the utilisation of research results. These networks should be created in collaboration with the various industry sectors, as well as with the final end-users. Collaboration should include interactions with decision-makers, industry, local researchers and international researchers.

Close interaction and collaboration between stakeholders is essential to guide the development of research agendas, as well as to increase the capacity of industry and end-users to absorb the technological or social advances. Collaboration has the further benefit of creating trust and confidence in the research findings.

Networks of innovation should be created around excellent scientific leadership. The surveys and case studies have indicated that the expertise and commitment of project leaders are important to ensuring that research findings are utilised and that unexpected findings are exploited. The appropriate human-resources skills base should be put in place within these networks. Existing experience within a research team should be used to develop human resources with a particular emphasis on the transformation agenda in terms of race and gender. The presence of young researchers within a team is also encouraged to allow the teams to move away from the traditional notion of ‘science push’ to one of ‘innovation pull’.

The network should be considered to be a programme with substantial funding. The programme would comprise a number of different initiatives, with a common goal.

Researchers and institutions that promote innovation should receive recognition of excellence. The present financial mechanisms that are utilised (for example, the rating of researchers by the National Research Foundation) should be encouraged to integrate the recommendations of this study, for example, by funding experienced scientists that have developed research protocols in collaboration with end-users.

HEIs should be encouraged to develop policies that encourage innovation and research. This would include encouraging ways of disseminating R&D results other than through academic publication. The teaching or service delivery load should be decreased for researchers that bring in substantial grants.

NACI’s role as the champion of innovation in the country was endorsed. However, a greater emphasis on its advocacy role within government and society was strongly recommended. NACI should advocate the integration of the recommendations of this study with available financial mechanisms. The recommendations would include giving priority to the funding of experienced scientists that have developed research protocols in collaboration with end-users. National and international research collaboration should be supported. Financial measures that encourage an increase in the capacity of industry to absorb researchers, as well as to conduct more R&D, should be explored.

4.3 Access Market International (AMI)

4.3.1 Methodology

A strategy for research utilisation was developed from extensive analysis of published information and synthesis of the survey of research outputs from higher education institutions (HEI's), science councils (SC's) and private organisations, conducted by CENIS, 2002-3, across a number of sectors of the South African economy. Secondly inputs were derived from case studies conducted by the CSIR/HSRC on research projects where the extent of utilisation was questioned and key findings analysed.

In addition to an extensive analysis of the results of the surveys and case study components of the project, AMI conducted some 22 stakeholder interviews (four with HEI, four with research experts of whom two were international experts, two with government, six with industry and six with science councils) to gain insights into research utilisation, across a representative range of high-level stakeholders. A set of key conclusions and preliminary recommendations was formulated and discussed in a strategy workshop with a select group of representatives from industry, academia and science councils. The outcome of the strategy workshop was a set of strategic recommendations and interventions as presented to NACI.

A modified version of the Bozeman model (Figure 2.3) was used as basis for the analysis of the information.

4.3.2 Strategy to improve research utilisation

Three themes or grand strategies provide the context for the formulated strategic objectives, in ensuring that they remain aligned with what is envisaged for strategy utilisation in the future. These are ***demand stimulation through investment in research initiatives***, ***collaboration and communication*** **and** ***research process effectiveness.*** From these themes, four main strategic objectives must be pursued over the long term. Each strategic objective is supported by a number of interventions or initiatives that are required for the strategic objective to be achieved (Tables 4.1 and 4.2).

Table 4.1: Strategic objectives and supportive interventions

SO1	**Stimulate innovation / technology development on the demand side (industry)**
SI 1.1.	Consider tax breaks for activities successfully completed throughout the commercialisation process
SI 1.2	Strengthen funds like THRIP and the Innovation Fund through streamlining and increased funding and streamlining
SI 1.3	Establish a Government venture capital/seed funding scheme
SI 1.4	Link research to incentives that will in turn promote collaboration
SO2	**Develop a supply side culture of commercialisation**
SI 2.1	Mandate HEI's to establish functions that support and encourage cross-functional entrepreneurship
SI 2.2	Revise and broaden the scientist recognition and grading system to include researchers and scientists in industry

SI 2.3	Change the performance management system of HEI's and SC's (at individual, department and organisation) level to include measures of utilisable research outputs
SI 2.4	Mandate HEI's and SC's to formalise IP policies and support structures
SO3	**Facilitate collaboration and alignment between HEI's / SC's and industry**
SI 3.1	Align research effort (funding, incentives, etc) with technology missions
SI 3.2	Establish R&D strategies for technologies within sectors not addressed in R&D strategy
SI 3.3	Encourage HEI's and SC's to promote capabilities and capacities to industry
SI 3.4	Optimise the roles and linkages of transfer programmes
SO4	**Improve the management and administration of research processes to improve utilisation**
SI 4.1	Recognise value of entrepreneurial and experienced researchers and implement actions to maintain
SI 4.2	Institutionalise formal "contracting" arrangements between research project and "client"
SI 4.3	Align portfolio of projects (in terms of size of funding) with expected utilisation levels

Two additional all-encompassing strategic initiatives not related to any one of the previous strategic objectives but essential to the overall realisation of the utilisation strategy were identified (Table 4.2).

Table 4.2: Aligned strategic initiatives

SI 5	Implement the R&D strategy support intervention
SI 6	Design and implement a research utilisation measurement system

4.4 An integrated summary of key strategic clusters

The main conclusions and recommendations for improving research utilisation in South Africa, as developed by each of the strategy groups, were presented and briefly elaborated upon in the previous section. In this section we present - in an integrated and synthesised manner – the complete set of detailed strategic objectives developed by these groups. The new set of objectives was derived by means the following process:

Step 1: The **sum total of individual strategic objectives** generated by the strategy consultants was "pooled" deleting any obvious duplicates.

Step 2: Utilising the **logic model framework**[2], strategies were "rewritten" according to the main headings of the framework, viz. statement of objective,

[2] The logic model framework is a well-known conceptual tool used in project management and programme evaluations. It is used as a framework to capture and represent the internal structure and

activities (the activities that need to be implemented to achieve the stated objective), the key actors (who must presumably implement these activities), the expected outcomes (the benefits that will accrue if the activities are successful) and the target group (the intended beneficiaries of that specific outcome).

***Step 3*:** **Clusters of strategies** were subsequently constructed, e.g. strategies aimed at funding, dissemination, venture creation, and so on. This process generated nine strategy clusters, viz.:

1. Funding
2. Institutional support, capacity building and research management
3. Research reward systems
4. Innovation and commercialisation policies and mechanisms
5. Venture capital
6. Create a utilisation "intent" in research projects
7. User needs
8. Collaboration within knowledge production
9. Collaboration between knowledge producers and users

In addition to a clustering of the proposed strategies, we have also organised the strategies according to the main stages in the research and innovation process. This has led to the following classification of the first 23 strategies:

- Strategies aimed at the knowledge production end of the process (1 -11)
- Strategies aimed more at the user end of the process (12 - 18)
- Strategies aimed at the interactions between producers and users of knowledge (19 - 23)

We should emphasise, however, that this classification does not mean that we revert back to an old supply-demand model of research utilisation. Precisely because the network model of research utilisation incorporates and subsumes the other models, it means that one is in effect saying that all the proposed strategies should be **re-interpreted** within the network perspective. An example: even strategies that would normally be seen as being completely directed at improving or expanding knowledge production (science push/supply side) such as more funding or project management training, need to be understood within the network model as having wider repercussions through the system. One way in, which this occurs, is through the statement of certain conditionalities (funding is conditional on collaboration or project management training should be aimed at improving networking).

The arrangement (systematisation in terms of the logical model framework and clustering) offers a number of obvious advantages. Firstly, this approach greatly helped getting an overview of the large range of recommended strategies. Secondly, the process clearly showed the cross-validation of the recommendations. Thirdly, it represents a useful tool for improving the utilisation of research findings to be used by those involved in research and research management. The tables are presented without discussion, since the information contained in them is self-explanatory.

---

logic of interventions. The application of the logic model framework to the strategies is unproblematic given that a strategy is a type of human intervention.

Table 4.3A: Improving research utilisation through measures aimed at the *knowledge production* (supply/ science push/ dissemination) side

CATEGORY	STRATEGIC OBJECTIVES	EXPECTED OUTCOMES	TARGET GROUP
I. FUNDING	1. Strengthen THRIP and the Innovation fund	Increased funding for research which has economic and commercial utility	R&D Performers
	2. Increase access to funding	Efficient funding approval system	Researchers/ research groups at HEI's and SC's
	3. Link funding criteria and rewards to national priorities	Researchers and research group carry out research in line with national priorities	Researchers/ research groups
II. INSTITUTIONAL SUPPORT, CAPACITY BUILDING AND RESEARCH MANAGEMENT	4. Increase institutional support	Increased institutional support	R&D performers R&D managers
	5. Recognise value of entrepreneurial and experienced researchers	Entrepreneurial and experienced researchers are recognised and rewarded	R&D performers
	6. Institutionalise formal "contracting" arrangement between research project and "client"	Standardised protocol which highlights performance and utilisation is used by all research projects	R&D managers R&D performers
	7. Ensure that research funds are managed effectively/ Improve the management and administration of research processes to improve utilisation	Clear research contracts in place More efficient management of project funds	R&D managers R&D performers
	8. Create, identify and retain good (research) leadership/ Build good research around good project leaders	Research projects are headed up and carried out by recognised, respected leader who has the following values and skills: commitment; flexibility; good communication; project management and is able to manage stakeholder relationships	R&D managers R&D performers Research groups at HEI's and SC's
	9. Train research leaders and research teams in project management and communication skills	More efficient research project management incl. better communication and dissemination of research results	R&D managers Researchers/ research groups at HEI's and SC's
III. RESEARCH REWARD SYSTEMS	10. Develop an enhanced recognition system	• Inclusion of researchers in commerce and industry in the current recognition system • Increase in utilisable research	Researchers in commerce and industry as well as HEI's and SC's
	11. Change performance management system of HEI's and SC's (at individual, department and organisation) level to include measures of utilisable research outputs[3]	Improved performance in HEI's and SC's in relation to defined research output categories and research utilisation	Researchers/ research groups at HEI's and SC's

[3] Da Vinci recommends importance of ratio of publications to patents

Table 4.3B: Improving research utilisation by focusing on *user driven* measures

CATEGORY	STRATEGIC OBJECTIVES	EXPECTED OUTCOMES	TARGET GROUP
IV. INNOVATION AND COMMER-CIALISATION POLICIES AND MECHANISMS	12. Develop a supply side culture of commer-cialisation in public research institutions	Increased partnerships with private sector facilitated by commercialisation departments	Researchers/ research groups at HEI's and SC's
	13. Develop appropriate innovation policy at HEI's and Sc's	Improved performance in HEI's and SC's in relation to research output categories and research utilisation	Researchers/ research groups at HEI's and SC's
	14. Mandate/encourage/ enable HEI's and SC's to formalise intellectual property policies and support structures	Clear/ intellectual property policies in place at HEI's and SC's	R& D managers
V. VENTURE CAPITAL	15. Provide more venture capital to researchers	Research projects able to access venture capital	R&D performers
VI. CREATE A UTILISATION INTENT IN RESEARCH PROJECTS	16. Assess the potential value of research for utilisation	Research projects carried out would be geared towards usability and in line with South African development and innovation priorities	Researchers/ research groups
	17. Align portfolio of pro-jects (in terms of size and funding) with expected utilisation levels	Clearer alignment of approved projects and technology imperatives	Researchers/ research groups at HEI's and SC's
VII. USER NEEDS	18. Stimulate innovation/ technology development on the demand side (industry)	Economic benefits for researchers/groups – utilisation of tax break incentive to carry out further research	Researchers/ research groups

Table 4.3C: Improving research utilisation through a focus on *linkages/ interactions* between users and producers of knowledge

CATEGORY	STRATEGIC OBJECTIVES	EXPECTED OUTCOMES	TARGET GROUP
VIII. COLLABORATION WITHIN KNOWLEDGE PRODUCTION	19. Institutionalise research collaboration	Increase in number of research projects carried out collaboratively	Researchers/groups at HEI's and SC's
	20. Promote international research collaboration	Increase in number of research pro-jects carried out collaboratively with international researchers/ groups	Industry and research groups/ researchers
IX. COLLABORATION BETWEEN PRODUCERS AND USERS OF KNOWLEDGE	21. Facilitate collaboration and alignment between HEI's, SC's and industry	• Improved alignment between re-searchers and users of research and easier identification of areas and opportunities for commercialisation • Research undertaken will be more aligned to technology missions??	Industry and research groups/ researchers
	22. Promote dialogue between users and producers of research	Improved communication between different stakeholders	Industry and research groups/ researchers
	23. Optimise roles and linkages of transfer programmes (GODISA, NAMAC Trust)	• Stronger links: transfer programmes and commercialisation centres • Increased number of transfer programmes	Industry and research groups/ researchers

4.5 Summary

The work of the strategy groups has produced a rich and wide variety of strategic objectives. In the first part of this chapter we have summarised the individual methodologies and processes used by the different agencies to produce their respective recommendations. The tables in the second part list in some detail (but organised into nine clusters) the individual strategies. It should be clear that different role players (researchers, project leaders, institutions, funding agencies, users of research information, and others) may use these tables as sources of information for designing research projects that would result in better utilisation of research findings.

In the final chapter of this report we present some ideas on the further implementation of these strategies.

CHAPTER 5

AGENDA FORWARD

The strategic objectives and recommendations presented in the previous chapter are quite detailed and clearly diverse in nature. While the tabulations that set out these objectives and recommendations identify the target groups at which they are directed, they do not indicate either responsibility or means for their implementation. Given that the present report is concerned with the utilisation of research findings, this is clearly an important aspect in need of specific consideration within this document. The challenge of implementing the findings of the present study is, accordingly, the focus of this chapter.

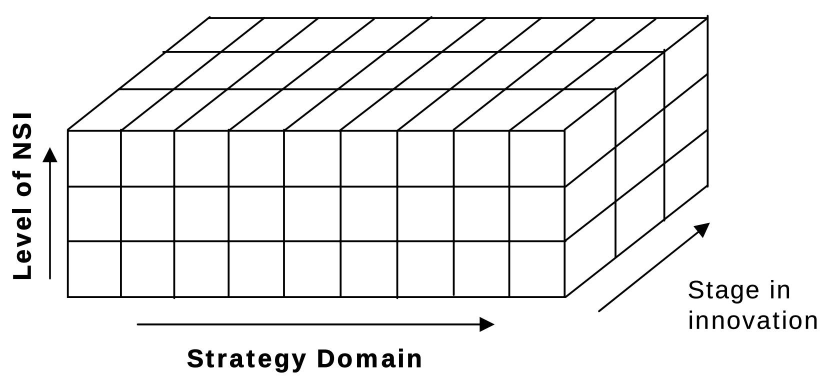
5.1 The number and multidimensionality of utilisation strategies

The first point that needs to be recognised is that this study has given rise to a large number of implementation strategies that fall into essentially one of three dimensions, namely:

- The strategy domain (for example, funding and collaboration)
- Level in the NSI (for example, macro, meso or micro)
- Stage in the research and innovation process (knowledge production phase, knowledge dissemination and diffusion phase, and knowledge uptake and utilisation phase).

Schematically, the various strategies can thus be represented in three-dimensional space, as shown in Figure 5.1.

Figure 5.1: Three-dimensional representation of strategies



This three-dimensional representation highlights the complexity that needs to be addressed when considering the implementation of the proposed strategic objectives. For instance, strategies at different levels of the national system of innovation may address different actors and agencies and have different intended target groups. Similarly, strategies located at different stages of the research and innovation process may require different implementation plans. Furthermore, the boundaries between levels and stages in the NSI are permeable, and a reasonable degree of flexibility must therefore be built into any implementation plan.

Having recognised the complexity of the task, it is perhaps equally important to recognise the practical challenge that must be met head-on. Stated simply, the challenge is to devise a limited number of strategic initiatives that will together serve as the instruments for securing the implementation of the bulk of the evidence-based strategies set out in the previous chapter.

5.2 Instruments for implementation

A detailed implementation framework should ideally specify not only the strategic initiatives, but also the potential costs and time frames of the implementation instruments and process. The framework set out below is far more modest, in that it is confined to an outline of the instruments that NACI should consider recommending as the means for implementing the findings of the present study.

5.2.1 R&D charter

Our first proposal is that an R&D utilisation charter be established for adoption and implementation by all organisations undertaking research. The charter would set out the principles that need to be implemented in the planning and execution of research, so that the research findings that emerge are well utilised in due course. The principles would reflect the essence of the wide spectrum of findings of the present study, which can or should be implemented by the executive management of such institutions. It would thus become the responsibility of management to appropriately handle the different dimensions considered earlier. Given that such utilisation makes obvious business sense, and that it would clearly be in the national interest, the charter should be promoted as a fundamental component of good research and technology management. It should be promoted for adoption by all organisations that undertake or fund research and technology development, within both the public and private sectors.

In the case of government-funded research and technology development, consideration should be given to making the adoption and implementation of the charter a requirement for all organisations funded totally or in part from government funds. All such institutions could be required to adopt and implement the charter within an appropriately limited time period, and to include a report on their implementation of the charter in their annual reports. An appropriate time period for the adoption and implementation of the charter might be one, or perhaps two, years.

While the charter would set out a clear statement of the principles, there would need to be flexibility in the manner in which the principles are implemented in practice. It would thus be appropriate to supplement the charter with guidelines in key areas where such guidance would facilitate and foster the implementation of good practice, and the findings of the present study.

5.2.2 Government policy directives on research funding and management

An examination of the strategic objectives and recommendations set out in the previous chapter shows that a number of them would need to be implemented by government. Examples of such recommendations include strengthening THRIP and the Innovation Fund, establishing venture capital and seed funding arrangements, and implementing some form of incentive scheme, such as the provision of tax credits for qualifying private sector research and development.

Accordingly, it is proposed that various of the strategic objectives and recommendations of this study be developed by the Department of Science and Technology into a set of policy directives for adoption by government. Given that a number of these policy directives would, if adopted, impact on other government departments and require their support, considerable consultation and collaboration with such departments would be required in the development of the policy directives.

While most of the policy directives would be concerned with funding arrangements, including the provision and management of such funds, it would be important to extend the directives to research performance management where appropriate. In particular, one such directive could encapsulate a requirement that all organisations that use government funds either to conduct or fund research and technology development be required to implement the proposed R&D charter.

5.2.3 Guidelines on performance management and project funding

While the R&D charter would set out the key principles of the performance management and project funding findings that emerged from this study, it is envisaged that some guidance may be needed for the effective implementation of these principles.

This guidance would be provided in a set of guidelines drawn up to complement and support the R&D charter. Such guidance would draw heavily on the experience of the case studies and other findings reported in this study. It should also take into account the input of experts from affected organisations, who should be invited to comment on a draft of the envisaged guidelines before they are finalised. In addition to gaining useful input from such experts, their involvement in the process of finalising the guidelines would greatly increase their ownership of the eventual product. The guidelines would follow the usual style of presenting the issues that need to be considered, as well as providing examples of established good practice, in a non-prescriptive manner.

5.2.4 Guidelines for creating Sectoral Networks of Innovation

We believe that the creation of Sectoral Networks of Innovation Programmes (SNIPs) will considerably enhance the utilisation of research results. In order to facilitate the creation of such networks, it is again proposed that a set of guidelines, including criteria for the success of SNIPs, be drawn up for this purpose.

These networks should be created in collaboration with the various industry sectors, as well as in conjunction with the final end-users. Collaboration should include interaction with decision-makers, industry and researchers, both locally and abroad. Close interaction and collaboration between stakeholders is essential to guiding the development of research agendas, as well as increasing the capacity of industry and end-users to absorb the technological or social advances. Collaboration has the further benefit of creating trust and confidence in the research findings.

Networks of innovation should be created around excellent scientific leadership. The surveys and case studies indicate that the expertise and commitment of project leaders are important in ensuring that research findings are utilised and that unexpected findings are exploited. The appropriate human resources skills base should be put in place within these networks. Existing experience within a research team should be used to develop human resources with a particular emphasis on the transformation agenda in terms of race and gender. The presence of young researchers within a team is also encouraged to allow the teams to move away from the traditional notion of 'science push' to one of 'innovation pull'.

In some respects, these Sectoral Networks of Innovation may be considered similar to the Australian Cooperative Research Centres. In developing the guidelines for creating these networks, relevant experience gained in the establishment and operation of the Australian Centres should thus be taken into account.

It is proposed that one or two SNIPs be developed and piloted, firstly to refine the guidelines as necessary, and secondly to establish the feasibility of implementing the concept more widely.

5.2.5 Creation of a national knowledge map

It is proposed that a national knowledge map be created and maintained to identify gaps and opportunities for conducting research and development with strong potential for utilisation. In many respects, the Technology Foresight Project, conducted several years ago by the Department of Science and Technology, may be regarded as already having initiated the creation of the envisaged knowledge map. The challenge that must now be addressed is that of reinvigorating the sector-wide consultation that was set up in undertaking the Foresight Project. This needs to be done, firstly with a view to the participants' benefiting from the outcomes of the process in the definition of their research activities, and secondly, with a view to evolving a process for regularly updating the knowledge map to take account of changing circumstances. This challenge should be addressed by the Department of Science and Technology.

5.2.6 Creation of a knowledge repository

Following on logically from our previous proposal, our next proposal is that a dynamic repository of South Africa's knowledge base be established. Such a knowledge repository should represent the strategic knowledge and innovation priorities and challenges of the country, and would perhaps best be housed within the Department of Science and Technology.

The ultimate aim and value of such a knowledge repository would be to encourage knowledge sharing among producers and users of research through the creation of various information channels, or pathways, through which researchers and potential users can interact. It is, however, key to foster a culture of knowledge sharing, and to encourage intellectual freedom to optimise the exposure of potential users – thereby maximising the potential for research utilisation.

In general, the design and implementation of a knowledge repository should attempt to achieve two objectives: (i) to integrate disparate knowledge structures and facilitate the creation of topic maps; and (ii) to promote user interaction with knowledge structures for more effective searching, browsing and navigation.

Domain-specific knowledge repositories: We propose that one or two pilot projects be initiated to test the idea of a knowledge repository in certain strategic domains (such as biotechnology or poverty research). Such pilot projects should comprise the following steps:

- Through a stakeholder analysis, identify the key producers and users of knowledge in that domain.

- Conduct a preliminary mapping of the knowledge products (such as scientific knowledge, technologies, patents, licences, interventions and programmes) in that domain.
- Develop the basic technical specifications and architecture of the repository.
- Conduct a feasibility study by developing a repository to scale.

In developing and testing the concept, specific consideration should be given to evolving structures and mechanisms that would allow the updating and expansion of the repository to occur as an integral process of conducting R&D. In respect of government-funded R&D, it could become a contractual obligation.

5.2.7 Knowledge utilisation barometer

This NACI study on the utilisation of research findings has to some extent established a baseline of the extent of knowledge utilisation in South Africa. Several of the experts consulted have recommended that an instrument be designed and developed to provide ongoing monitoring and evaluation information on the extent of knowledge utilisation.

We propose that a knowledge utilisation barometer, or index, be developed to address this need. We believe that such a barometer should meet the following criteria:

- It should be conceptually grounded in the work done by the NACI study (for example, by incorporating a broad notion of knowledge utilisation).
- It should be a valid and reliable index of the extent of utilisation.
- It should be a cost-effective instrument.
- It should be applied regularly so as to produce regular time-series information.

The development of this barometer should be tackled as a future NACI project, with a view to arriving at a recommendation that the barometer be used by NACI, the Department of Science and Technology and other government institutions concerned with cost-effective investment in research and development.

5.3 Conclusion

This NACI study on the utilisation of research findings has produced comprehensive and detailed information, both on the state of utilisation of such findings in the South African system of innovation, as well as on a wide range of desirable strategies for improving both the quantity and quality of the utilisation of research findings. The strategies proposed in the previous chapter and the implementation instruments outlined above are consistent with various recent government initiatives, for example, to increase research output, to improve the responsiveness of higher education to national goals, and to align the research of science councils more with macro-economic concerns. We believe that this study not only provides a strong rationale for the intrinsic value of utilisation-focused research and development, but also outlines a number of realistic ways of achieving this outcome.

REFERENCES

Beesley, L.G.A. (2003) Science policy in changing times: Are governments poised to take full advantage of an institution in transition? *Research Policy* (forthcoming).

Bozeman, B. (2000) Technology transfer and public policy: A review of research and theory. *Research Policy*, 29: 627-655.

DACST (1996) *White paper on science and technology*. Cape Town: Government Printer.

David, P.A. and Foray, D. (2002) *Economic fundamentals of the knowledge society* (mimeograph).

Department of Arts, Culture, Science and Technology (1996) *White paper on science and technology: Preparing for the 21st century*. Pretoria: Government Printer.

Department of Education (1997) *Programme for the transformation of higher education: Education white paper 3*. Pretoria: DoE.

Department of Science and Technology (DST; 2002) *South Africa's national research and development strategy*. Cape Town: Government Printer.

Department of Science and Technology (DST; 2003) *Annual report 2002/03*. Pretoria: DST.

Freeman, C. (1987) *Technology policy and economic performance: Lessons from Japan*. London: Printer.

Innovation Fund (2003) *Annual report 2002/03*. Pretoria: NRF.

Lall, S. (2003) Indicators of the relative importance of IPRs in developing countries. *Research Policy.* (In Press, Corrected Proof, Available online 12 April 2003.)

Landry, R., Amara, N. and Lamari, M. (2001) Utilisation of social science research knowledge in Canada. *Research Policy*, 30.

Marais, H.C. (2000) *Perspectives on science policy in South Africa*. Menlo Park: Network Publishers.

Nasierowski, W. and Arcelus, F.J. (2003) On the efficiency of national innovation systems. *Socio-Economic Planning Sciences*, 37.

National Research Foundation 2003. *Annual report 2002/03*. Pretoria: NRF.

OECD (1992) *Technology and the economy: The key relationships.* Paris: OECD.

Richmond, B. *Introduction to systems thinking*. (www.hpsinc.com)

Ruivo, B. (1994) 'Phases' or 'paradigms' of science policy? *Science and Public Policy,* 21(3): 157-164.

Sharpe, L.J. (1977) The social scientist and policymaking: Some cautionary thought and transatlantic reflections. In Weiss, Carol H (Ed.), *Using social research for public policy making.* Lexington MA: D.C. Heath. Pp. 37-54.

Stetler, C.B. (2001) Updating the Stetler model of research utilisation to facilitate evidence-based practice. *Nursing Outlook*, 49(6).

Weiss, C.H. (1980) Knowledge creep and decision accretion. *Knowledge: Creation, Diffusion, Utilization,* 1(3): 381-404.

Wickham, S. (2002) *Unlocking intellectual knowledge: External partners' views of research partnerships with selected higher education institutions in the Western Cape.* Report for the International Development Research Centre / Trade and Industry Policy Secretariat. Cape Town: Research & Academic.

Appendix 1

List of companies per sector interviewed

AGRICULTURE, FORESTRY, FISHING AND HUNTING	MINING
Astral Foods (Meadow Feeds)	AECI - African Explosives
Citrus Research International	Amplats Research Centre & Process Techn Div
Kynoch Feeds	AngloGold - Engineering
Mondi Forests Ltd	AngloGold -GeoChemistry
Mondi processes	AngloGold - Metallurgy
Pannar	Billiton Process Research
SAPPI	De Beers
Sugar Milling Research Institute	De Beers Diamond Research Laboratory
CONSTRUCTION	Impala Platinum: Exploration & projects
Infraset (Grinaker - LTA)	Impala Platinum: Metallurgy
Mitek	Impala Platinum: Mining
Murray and Roberts	Impala Platinum: Refinery
MANUFACTURING (Food, drink and tobacco)	ISCOR Mining Consulting Services (Kumba Res)
Anglovaal Industries - I & J	**MANUFACTURING Textiles, apparel & leather**
Anglovaal Industries - National Brands Ltd	AECI - Fibres: SA Nylon Spinners (CT)
Capespan	Bergriver Textiles Mngr new product developm
Clover	Breathe Techs Corp
Distillers Corp - Stellenbosch	Gelvenor Textiles
Illovo	Kaytech
Parmalat	**FABRICATED METAL PRODUCTS & MACHINERY: Metal products**
Pioneer Foods	Columbus Stainless
Reckit Benckiser (& Colman)	Dorbyl Engineering
SA Breweries	Huletts Aluminium
Tiger Foods (nee Langeberg Food Ltd)	South African Institute for Steel Construction
Tongaat-Hulett Sugar	SERVICES AND INFRASTRUCTURE
Unilever Best Foods Robertson	CELL C

MANUFACTURING Paper, print & publishing	ESKOM
Nampak - Megapak	
FABRICATED METAL PRODUCTS & MACHINERY: computers & office machinery	**FABRICATED METAL PRODUCTS & MACHINERY: radio, TV and communication equipment**
Azisa	Aberdare Cables
ISIS	ALTRON: Altech - UEC technologies
Nanoteq	ALTRON: Altech - Netstar
Quality and Reliability SA	Digicore Technology
Spescom	Eloptro
African Cables	Fuchs Electronics
Circuit Breaker Industries	Grintek Avitronics
Conlog	Grintek Communications
Genwest &Hansen	Grintek Electronic Systems
Impro Technologies	Grintek Electronics
Willards Batteries	Reutech Radar Systems
	Siemens Telecommunications
FABRICATED METAL PRODUCTS & MACHINERY: Shipbuilding and repairing	Tellumat (previously part of Plessey)
Dorbyl Engineering	Thales Advanced Engineering (Fran)
Dorbyl Engineering - Shipping	
National Ports Authority	**FABRICATED METAL PRODUCTS & MACHINERY: Aircraft**
FABRICATED METAL PRODUCTS & MACHINERY: Motor vehicles	Altech Defence Systems
DELTA Motor Corporation	Denel Aviation
Toyota	Denel Ordnance (8 subsidiaries)
Volkswagen of SA	CHEMICALS: drugs and medicines
CHEMICALS: chemicals excluding drugs	Aspen Pharmacare
AECI - Aroma and Fine Chemicals	Aventis (Hoechst Marion & Roussel)
AECI - Bioproducts (Umbogintwini)	Bristol Meyers Squibb
AECI - Specialty Chemicals = ChemServe	Meyer Zall Laboratories
Eli Lilly Pty Ltd	Pfizer Global R&D (Fran)
Fine Chemicals Corporation	**CHEMICALS: petroleum refineries & products**
Lever Ponds	Keyplan Engineers and Suppliers of Separation Techn
Novartis: Pharma	Petro SA
Unilever	Plascon (Barlow World)
	Sasol – Sastech
CHEMICALS: rubber and plastic products	**TRANSPORT**
DPI Plastics	South African Airways

Appendix 2

Panel Members (Da Vinci Technology)

The following individuals formed the panel:

- Dr MS Jeenah — Independent policy consultant
- Dr N Segal — Head of Graduate School of Business, UCT
- Prof E Preston-Whyte — Ex-Deputy Vice-Chancellor, University of Natal
- Dr R Maharaj — Policy analyst, CSIR
- Prof P Ngoepe — University of the North
- Dr R Skeef — Group Executive, National Research Foundation,
- Mr M Myers — Engineering and business consultant.

Appendix 3

List of interviewees (Da Vinci Technology)

The following individuals were interviewed:

- Dr A Paterson — DST Chief Operating Officer
- Dr D Kaplan — DTI Chief Economist, NACI
- Dr S Lennon — Eskom Executive Director R&D, NACI
- Mr I Robertson — BMW CEO
- Mr H McClusky — Altech Group Executive Multi-media/IT
- Mr B van de Merwe — Sappi Director of R&D
- Mr J Burns — Godisa CEO
- Mr P Pelser — Parsec CEO

Appendix 4

SOUTH AFRICAN POLICY CONTEXT

The following paragraphs, firstly, offer a few milestones in the emergence of utilisation as a significant objective of and criterion for publicly funded research in South Africa, secondly, highlight its position in national policy and strategies, and thirdly, briefly refer to utilisation policies and strategies at three science councils.

Before 1986

From the time they were founded up until about 1986, most science councils operated in the spirit of Vannevar Bush's 'endless frontier' and were largely dependent upon government for their funding. Most of their research programmes were self-initiated, although many were of an applied nature.

The majority of projects supported by government research funding agencies could be described as self-initiated basic research. Both the CSIR and the HSRC managed cooperative problem-oriented research programmes as separate components of their research funding portfolios.

Government departments and other statutory bodies invested heavily in research aimed at making the country strategically self-sufficient in military capability, energy and food, for example. The work of Armscor and Sasol may be noted in this regard.

In 1983, the Science Advisory Council commissioned an investigation into the dynamics of the implementation of research findings to serve as an additional criterion for the equitable distribution of public research funds. The study, which was completed in 1989, essentially consisted of case studies and longitudinal field studies.

1986–1994

The introduction of framework autonomy in 1988 (which restricted public funding and required science councils to grow as a function of their self-generated contract research) in a sense represents a significant and explicit steering towards problem-oriented research. The result of this change in the course of public funding was sharp increases in contract income and a shift in focus towards relevant research, the results of which could be used – in certain respects, the ideal became technology development, even in the case of the social sciences.

An overview of the development of science policy before 1994 can be found in Marais (2000).

Post-1994

Three more or less distinct phases in the role of the utilisation in R&D policy can be distinguished since the inauguration of the first democratic government in South Africa in 1994, namely, the general commitment to have S&T contribute to national development, initially captured in the White Paper on S&T and subsequently elaborated in the National R&D Strategy in 2002. Parallel to these developments, new policies for higher education were being developed, for example, as reflected in the third white paper on higher education. The following paragraphs offer relevant references to what could reasonably be interpreted as pointers to the realisation of the importance of utilising research findings.

Innovation policy and strategy

Both the White Paper on S&T and the National R&D Strategy are fairly clear on the need to put the findings of research to good use in promoting economic development and improving the quality of life of South Africans. The following points taken from the White Paper are relevant:

- The policy's ambit is significantly broadened to include innovation, defined as the transformation of knowledge into such outputs as usable products, processes and services, with the emphasis on implementation and application.
- The role of S&T is identified as "…central to creating wealth and improving the quality of life in contemporary society" and the "…promotion of research … is crucial to innovation and hence to both social and economic development", especially in areas such as competitiveness and employment creation, quality of life, development of human resources and environmental sustainability.
- The new policy provided for two important mechanisms, namely, the Innovation Fund, initially administered by the Department itself, and NACI. The mission of the Innovation Fund is set out in its most recent annual report (2003) as promoting "the economic competitiveness of South Africa through investments in technological innovations that lead to the establishment of new enterprises … to the benefit of all South Africans".
- The DST, in collaboration with NACI, in 2001 introduced a balanced scorecard approach to performance management in the science councils. In the current context, it is significant that customer satisfaction (i.e. the client and/or user of research) is one of five perspectives constituting the evaluation system.
- The Department of Science and Technology has also launched other programmes that promote the utilisation of knowledge (see DST 2003). Two of these programmes are the GODISA Incubator and Innovation Programme (incorporating eight incubator centres, one technology demonstration centre and one innovation support centre) and the Tshumisano Technology Stations Programme, which allows SMMEs to share the knowledge, innovation capacity and equipment of technikons. There are currently seven such stations.

The National R&D Strategy further reinforces the importance of the optimal utilisation of research findings in national policy and strategy, as the following selection clearly shows:

- The conceptual framework of the R&D strategy posits that R&D impacts on society through innovation, the outcomes of which are improved quality of life and economic growth (2002: 19, 37, etc.).
- The policy framework for science and technology is premised on the principle of innovation pull rather than science push (2002: 19).
- One of the three objectives of the R&D strategy is "the establishment of new technology missions aligned to quality of life goals and economic and industrial goals" (2002: 23), the other being increasing investment in the science base and the creation of an effective government science and technology system.
- The new technology missions are: poverty reduction, key technology platforms (namely, biotechnology and information and communications

technology), advanced manufacturing and knowledge, and technology for resource-based industries.

The South African government has over the past ten years also launched other programmes that directly and indirectly promote innovation and thereby also encourage the utilisation of research findings. A good example is the Technology and Human Resources for Industry Programme (THRIP), which facilitates joint research between higher education institutions and industry, funded by the Department of Trade and Industry (DTI) and administered by the NRF.

Higher education policy

Since the end of the Second World War, South Africa has developed a strong research tradition at universities. Although basic research has always been at the centre of the research missions of universities, applied and strategic research and technology development have emerged as important additions to the research missions. These have formed the focus of technikon research since that sector obtained a research mandate in 1981. The research policies and strategies of virtually every higher education institution emphasise the importance of directing research towards addressing national problems, while the annual research reports of many today reflect a growing portfolio of such activities as contract projects, patents and collaborative ventures with science councils and business – all indicators of a sensitivity to the need for the implementation of research findings.

At least four important co-producers of this emerging reorientation can be listed.

- The first factor in prompting the growing involvement in contract research would be the decline in public funding of research since the end of the 1980s and early 1990s, which forced institutions to look elsewhere to supplement their funding needs.
- A second factor would be an increasing awareness of international developments abroad, such as the emergence of what is generally described as Mode 2 knowledge production, or strategic science.
- A third and very important development is undoubtedly the new higher education policy and its inclusion of knowledge users in the research system. The third white paper on higher education of 1997, for instance, had this to say about the challenges facing the research system: "It must redress past inequalities and strengthen and diversify research capacity. It must also keep abreast with the emerging global trends, especially the development of participatory and applications-driven research addressing critical national needs which requires collaboration between knowledge producers, knowledge interpreters and knowledge managers and implementers." This very important statement represents the key objectives of the transformation of research in the higher education system.
- The fourth co-producer of this emerging reorientation is undoubtedly the new research funding strategy of the NRF, which through its core fund steers research towards addressing national problems. (This strategy is summarised later in the discussion.)

The higher education sector has clearly moved from being primarily involved in basic research, where utilisation was mostly in the form of publications, to various forms of problem-oriented research, ranging from applied research through to technology development, where interaction with end-users is critically important.

Institutional policies, strategies and practices

Brief reference is made to the approach to utilisation by three science councils, namely, (i) the national funding agency, the NRF, (ii) the Medical Research Council (MRC), which has the dual function of funding research and conducting its own in-house research, and (iii) the CSIR, which is an exclusively research performing institution. There are clearly significant differences between the eight science councils, but these three examples give some indication of the general orientation towards the utilisation of research findings obtaining in this sector.

National Research Foundation (NRF)

The NRF is currently the main government funding agency of research and development in South Africa. After extensive consultations, the NRF in 2001 announced a new strategic course in its funding of research and development. The following elements of the NRF's strategic plan, taken from its 2002 annual report, can be highlighted.

Corporate core mission: The mission specifies the foci of high-quality human resources and state-of-the-art infrastructure, as well as the following two utilisation related ones:

- The generation of high-quality knowledge in prioritised areas that respond to national and continental development needs
- The utilisation of knowledge, technology transfer and innovation to ensure tangible benefits to society from the knowledge created.

Focus areas: NRF funding is awarded through its Research and Support Agency (RISA), and is organised around nine focus areas, the following seven of which are directed towards national and continental problem areas:

- Conservation and management of ecosystems and biodiversity
- Economic growth and international competitiveness
- Education and the challenge of change
- Indigenous knowledge systems
- Information and communication technology and the information society in South Africa
- Socio-political impact of globalisation
- Sustainable livelihoods: Eradication of poverty.

The annual report goes on to say: "The focus areas form the landscape for interventions addressing the uniquely South African requirements for human resource development, knowledge generation, research utilisation, technology transfer and innovation..." (2003: 19).

The NRF further assists two government departments "...to facilitate the utilisation of research technology development, technology transfer and innovation through the management of the following two programmes:"

- Technology and Human Resources for Industry Programme (THRIP, which is funded by the DTI), the primary purpose of which is to enhance the competitiveness of the country
- The Innovation Fund (IF, funded by DST), which is aimed at enhancing technological innovation in selected fields.

Medical Research Council (MRC)

The MRC is South Africa's premier health and medical research institution. Its core mission is to improve the status of the nation's health through its research, thereby promoting equity and development. It has a dual supporting role in socio-economic development. Its core function is to perform research aimed at the health sector in order to improve and develop effective, affordable and equitable health care. The MRC also supports economic development through poverty reduction, the implementation of innovations in the health sector (new drugs, devices and systems) and contributing to the improved health and well-being of the economically active population. These two foci imply that the utilisation of research findings should be a key driver, as the following MRC projection regarding the South African Aids Vaccine Initiative shows: if successful, the MRC believes that the initiative could save the country more than R100 billion over a period of a decade and result in the saving of 20% of lives.

The MRC has clustered its research into six national research programmes, at least four of which directly address major South African challenges, namely:

- Environment and development
- Health systems and policy
- Non-communicable diseases
- Women and child health.

The importance of the utilisation objective is underlined by the fact that the organisational structure includes the specialised executive portfolio of Technology and Business Development (including intellectual property).

Council for Scientific and Industrial Research (CSIR)

The CSIR changed direction from an 'endless frontier' type research institution to a technology development one, driven by business principles, as long ago as 1987. This is perhaps best epitomised by its motto: 'Your technology partner'. Since then, it has consolidated its strategies and structures to the extent that questions are being raised as to whether it has not veered too far away from research as knowledge production.

The CSIR is mandated by statute to engage in directed and multidisciplinary research in the national interest of advancing industrial and scientific development and technological innovation, to contribute to the improvement of the quality of life of the people of South Africa. The CSIR invests in the establishment, expansion and maintenance of technological competences to fulfil its mandate either by itself, or in partnership with public and private sector institutions. The CSIR aligns its research agenda with national policies and strategies such as the National Research and Development Strategy, the Integrated Manufacturing Strategy and the Biotechnology Strategy, among others, to ensure that its research results meet the socio-economic demands of South Africa. As the CSIR works across market sectors and straddles traditional academic domains, its measures of research utilisation span the use of a range of instruments, including bibliometrics, client satisfaction, science and technology quality, and wider measurements of impact. These output and outcome measures feed into the organisation's planning cycle by influencing performance reviews and investment decisions. The integrity of this process ensures that the CSIR's portfolio of research activities is managed efficiently and is aligned with South Africa's changing needs.

Conclusions

South Africa's pre-1994 research orientation was a dualistic: at funding and management levels, self-initiated research (with a knowledge production orientation) and applied research (with a user orientation) were promoted as separate programmes, within and between R&D organisations. The fact that the importance of research utilisation was emerging as a criterion was clear, however, even if one of the few indications was the Science Advisory Council's consideration of commissioning an implementation study.

The new post-1994 S&T policy is quite clear in at least three respects about the importance of publicly funded research being relevant in contributing to economic growth and the improvement of the quality of life of all South Africans:

- Firstly, the scope of the new S&T policy was broadened to an innovation policy and, of necessity, the ambit of the system also widened to become an all-encompassing national system of innovation (NSI). Bearing in mind the definition of innovation, this has arguably been the most significant commitment at national policy level to the utilisation of research findings. This commitment has found expression in a number of programmes and instruments launched since 1996. This thrust has become even more crystallised in the recent National R&D Strategy.
- Secondly, the new Department of Arts, Culture, Science and Technology (Department of Science and Technology, since August 2002) provided various instruments to monitor the adherence to national policy by R&D institutions. Two of the most important of these are comprehensive institutional evaluations every three years and annual reporting on key performance indicators.
- Thirdly, the missions, strategic objectives, business plans and (in some cases) the organisational structures of science councils provide for relevant research and development and, ideally, the utilisation of research findings. To varying extents, this also applies to the more research-oriented universities and technikons.

It would be fair to conclude that South Africa is, both implicitly and explicitly, firmly committed to the ideal of promoting the utilisation of research findings. However, this conclusion is not insensitive to important nuances in the intention, expression and implementation of national policy in this regard; neither does it deny the slow adoption to the new directions in isolated quarters of research-performing institutions.

Appendix 5

SELECTED INTERNATIONAL CONTEXT

In the course of this study, the question arose as to how salient the challenge of the utilisation of research findings was in other countries. The question was very relevant, considering the apparent drift internationally towards Mode 2 knowledge production (Gibbons) or strategic science (Rip) over the past two decades or more. It was finally decided not to extend the scope of the present study to include international comparisons, however, but to include some references to policies, strategies or arrangements (really not more than traces) in selected countries. The following paragraphs offer a brief listing of initiatives with regard to the promotion of better utilisation of research in Australia, Canada, Egypt, Japan, Pakistan and the Netherlands. The systemic levels are not constant across countries.

Australia

Backing Australia's Ability, an action plan released in 2001 to promote research, development and innovation, provides an overview of measures to strengthen the S&T system in that country. Two elements of the strategy are to strengthen the ability to generate ideas and undertake research and to accelerate the commercial application of these ideas. Measures to attain the latter goal include:

- Reforming the tax incentive scheme to encourage business to increase its R&D investment
- Increasing investment in Cooperative Research Centres
- Pre-seed funding to facilitate the commercialisation of publicly funded research
- Improving intellectual property management in public research agencies.

The above and other measures clearly show that using R&D for economic and social development lies at the core of the strategy.

Canada

Canada has been very active in promoting the utilisation of research over the past decade, as the following two examples clearly show.

- The 1996 federal strategy, *Science and Technology for the New Century*, identified job creation and improved quality of life as two of the goals to which S&T resources should be directed, "…to ensure that Canada is among the best in the world in applying and commercializing S&T for sustainable job creation … (and) … to ensure that Canada applies S&T to improve the quality of life of our citizens…".
- The mandate of a 1999 report, *Public Investments in University Research*, by the Advisory Council on Science and Technology, was to identify ways of maximising the economic and social return on publicly funded university research. The report generated six recommendations, including steps such as the following: explicit commitments from publicly funded researchers to optimise the possible benefits of their research; the inclusion of innovation as a fourth university mission (the others being teaching, research and community service); and the review of tax policy to support research-based innovation.

- A 2002 framework agreement on federally funded research shows that, among other things, universities would double the amount of research undertaken and triple the amount of commercialisation by 2010.

Egypt

The Egyptian science system offers a good example of how the utilisation of findings forms an integral part of the public funding of research. In brief, the system works as follows:

- Relevant challenges and targets of the government's national economic plan are operationalised to form the set of research priorities for a particular period.
- The research community can then compete for funding of projects by the Academy of Scientific Research and Technology, the main government research funding agency.
- Research project proposals (especially for large projects) must include draft plans for implementing the project findings if the project is successfully completed.

Although information on the extent of successful utilisation could not be found, it is clear that planning for utilisation is regarded as an important element in competing for public research funds.

Japan

A system focused on research excellence can still include utilisation as one of its drivers, as the Japanese science and technology system shows. The 2002 annual report of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) gives a very useful summary of the *Second Science and Technology Basic Plan* for the period 2001 to 2005. The Plan centres around basic research, but does refer to the importance of the utilisation of research findings, as the following excerpts from the MEXT annual report show:

- Under the policy objective of the promotion of "S&T as a prior investment toward the future", quick utilisation and feedback to society is listed as one of the mechanisms.
- The basis for R&D prioritisation is identified as national and social needs, with the emphasis on such areas as life sciences, information technology, environmental science and technology.
- The coordination of cooperation between industry, academia and government is strongly promoted in order to "put the outstanding results of research conducted by universities and national research institutions, etc. into practical use" and contribute to the further development of society.

It would be fair to conclude that while the S&T policy of Japan focuses on promoting research excellence, it is inspired by the need for R&D to contribute to international competitiveness and the further improvement of the quality of life of the people, hence the references to utilisation.

Pakistan

Over the past few years, Pakistan has focused sharply on modernising and expanding its S&T system. Human resources development and the upgrading of research infrastructure have received special attention. This process has been accompanied by sensitivity towards the need to implement research findings as a contribution to economic development and improved quality of life, as demonstrated by the fact that a recent medium-term plan for R&D emphasised the need for demand-driven research and the commercialisation of R&D findings.

The Netherlands

The Dutch orientation to S&T policy seems to reflect a dynamic balance between research as knowledge production and the use of research for objectives such as economic growth and social development, as the following two references show:

- The Dutch Advisory Council on Science and Technology Policy has addressed the issue of knowledge utilisation directly and indirectly in a number of contexts. It recommended, for instance, that the utilisation of knowledge, rather than patenting, be defined as an important focus of universities. Instruments for promoting such utilisation include contract research for companies and the exchange of researchers with companies. According to the council, the extent and quality of interaction with business should become a permanent criterion in the assessment of universities.
- In its overview of the science budget of 2000, the Dutch government paid special attention to cooperation between the various role players in the S&T system. It concluded that there are still weaknesses in cooperation between publicly funded research and practice, and went on to list the following problem areas: knowledge users perceive the research system as not being transparent; some social sectors under-utilise available knowledge; and a weak relationship exists between research and application.

Conclusion

The above examples indicate that the utilisation of research findings is a fairly common policy objective and that it seems to be growing in salience. This trend would undoubtedly stand out in even sharper relief if this selective overview included references to explicit innovation policies.