SOUTH AFRICAN INNOVATION SURVEY 2001
for manufacturing and services

INDUSTRIAL INNOVATION IN SOUTH AFRICA 1998 - 2000

REPORT ON THE SOUTH AFRICAN INNOVATION SURVEY FOR THE PERIOD 1998-2000

December 2003

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Foreword

South Africa, alongside a number of forward-looking countries, has adopted a National System of Innovation. The fact that government has identified innovation as a key driver for economic growth must be seen in the light of a number of strategies aimed at reinforcing the concept, as well as to provide an incentive for public and private sector operations to stimulate innovation in their own environments. It is perhaps fitting to note that in the South African context innovation is defined as:

"The process of transforming an idea, generally generated through R&D, into a new or improved product, process or approach, which relates to the real needs of society and which involves scientific, technological, organisational or commercial activities"

Key to this definition is the fact that the innovation process is only complete once a defined product, process or system, which has some tangible benefit, is evolved. This definition therefore dispels some commonly accepted notions that often confuse invention with innovation.

Developing a policy framework is one thing, being able to assess the impact of such initiatives is an entirely different challenge.

It is for this reason that I would like to commend this research study. The study is founded on sound research principles and covers a sufficiently broad spectrum of industrial sectors to lend credence to the findings. The study provides a very useful framework for further debate and will, I am sure, be used as an important guideline for the review of key strategies adopted by both government and private sector organisations. The team has derived some important deductions providing some very encouraging and likewise some concerning signals as to the future of this country.

Professor Roy Marcus

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Pretoria/Eindhoven/Tilburg
December 2003

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Abbreviations and Acronyms

CIS	Community Innovation Survey
CPB	Centraal Plan Bureau
DACST	Department of Arts, Culture, Science and Technology
DG	Directorate General
DTI	Department of Trade and Industry
ECIS	Eindhoven Centre for Innovation Studies
EU	European Union
FRD	Foundation for Research Development
GDP	Gross Domestic Product
GERD	Gross Expenditure on R&D
ISP	Industrial Strategy Project
ITI	Institute for Technological Innovation
MC	Manufacturing Census
NACE	Nomenclature générale des Activités économiques dans les Communautés Européennes (General Industrial Classification of Economic Activities within the European Communities)
n.e.c.	Not earlier classified
NGO	Non-Governmental Organisation
OECD	Organisation for Economic Cooperation and Development
R&D	Research and Development
SADC	Southern African Development Community
SAIS	South African Innovation Survey
SIC	Standard Industry Classification
SISAMF	Survey of Innovation in South African Manufacturing Firms
SPII	Support Programme for Industrial Innovation
THRIP	Technology and Human Resource for Industry Programme
UP	University of Pretoria
USA	United States of America

Executive summary

Innovation - the introduction of new and/or improvement of products, services and production processes - is the driving force of a nation's economic development and the improvement of competitiveness of its firms. In South Africa, there is a growing awareness, not only among entrepreneurs, but also among policy makers and scientists, that innovation should be in the centre of attention of business and policy strategies. In order to formulate such strategies and policies, it is important that there is a clear picture of the economic and innovative performance of South African companies.

Existing data sources, such as national R&D surveys, are widely recognised as being inadequate to develop policy and support analysis in the area of innovation. As a result, a number of countries, including South Africa, have recently begun to measure innovation more broadly.

The South African Innovation Survey 2001 (SAIS2001) is the first comprehensive innovation survey conducted in South Africa. It was conducted during 2001/2002 by the University of Pretoria, in close cooperation with the Eindhoven University of Technology in the Netherlands. The survey was modelled on the European Community Innovation Surveys (CIS) conducted in European Union countries since 1994. The purpose of the survey was to get a representative, nationwide overview of the innovative behaviour and performance of South African firms in manufacturing and services in the period 1998-2000.

In SAIS 2001 a *stratified random sample* of 7039 firms were selected from a commercial database of South African firms and were asked to fill in the survey questionnaire. Of these, 617 or 8.4% completed the questionnaire. A second survey of 416 non-responding firms were conducted and showed no significant differences in the responses to a number of key questions and therefore the response group can be considered as representative of the total population of South African firms. The survey results were further weighted by the Manufacturing Census 1996 firm size distribution figures, to ensure that the findings would accurately describe innovation and innovative activities of the entire South African industrial base.

The survey found that about 58% of all firms were in manufacturing, whereas 23% were service providers and 19% of the firms were involved in wholesale activities. The majority of firms were small and medium-sized organisations. Only 7% of the firms employed 250 or more employees in 2000. Notwithstanding an average annual growth of sales of +2.3% in nominal terms (not deflated), employment contracted by about 7% during the period 1998 to 2000. About 11% of firms exported 50% or more of their sales. About 81% of the firms were involved in the production of products and services, and about 73% of the firms were involved in the marketing, distribution and sales of own products or services. Of these, 22% were using foreign sources of production technology (e.g. production licences).

About 44% of South African firms had technological innovations in the period 1998-2000. This figure is surprisingly high as it is comparable to that of many developed countries in Europe. The majority of innovations of South African firms were incremental and larger firms had higher innovation rates than smaller firms.

A relatively large part of the development of new or improved products and/or services was done by or together with a third party (32%), indicating a dependency on external knowledge and contributions. For process innovations, this percentage was much lower (18%).

The main reasons non-innovating firms gave for not innovating point to a lack of resources in terms of money, staff and time for innovation projects. The same factors hampered the innovating activities of innovating firms. About 40% of innovating firms experienced seriously delayed innovation projects due to a lack of qualified personnel and information/familiarity with technologies, high costs, economic risks and shortage of finance and time to market problems.

The R&D effort by firms in South Africa was generally low. About 51% of firms had no R&D effort. The mean R&D effort in persons was only 1.8% and 1.55% of total sales was allocated on R&D related innovation activities. Firms spent about 1% of total sales on non-R&D innovation activities, such as the purchase of

machinery & equipment, outsourcing research, innovation implementation, licences, innovation related marketing and training. Total innovation expenditures amounted to 2.6% of total sales. Again it was found that small firms spend higher proportions of their sales in innovations than larger firms.

About 18% of innovating firms actively work together with South African partners on innovation, which is significantly lower that the proportion of European firms that forms partnerships. Suppliers were most often mentioned as domestic innovation partners, followed by consultants, buyers, competitors and the own enterprise group. About one in every four innovating firms (26%) participated in innovative partnerships with organisations outside South Africa. Active innovative cooperation occurred in particular within the own enterprise group, and with suppliers and buyers. It was observed that there existed a strong tendency to cooperate with partners located in Europe.

The effects of innovation on a firm's market position can be considered as a subjective indicator of the impact of innovation on the competitive power of a firm. About 31% of South African innovators reported that their relative market position improved substantially due to their innovative activities. It was found that about 30% of total sales in 2000 could be attributed to innovated products and services. A recent Dutch innovation survey (CPB, 2002) showed comparable figures for Dutch innovating firms. South African innovators reported that about 13% of sales in 2000 was realised with products and services that can be labelled as "new to the market". The share of innovative sales realised with innovation new to the market of Dutch innovation firms is 14% (CPB, 2002), An unexpected conclusion is that South African innovating firms are able to produce innovation outcomes, which are comparable to European levels.

In conclusion, the South African industry can be characterised as being predominantly engaged in the improvement of products and processes using foreign technology. South Africa can therefore be characterised as a type of technological colony whose industries are dependent on foreign technology for the improvement of its products and processes. The primary mode of innovation seems to be imitation rather than invention.

1. INTRODUCTION

1.1 Innovation and innovation surveys

In order to build on the democratic political momentum of the new South Africa, it is vitally important that the economy must grow. In order to accomplish economic growth, the country will need to rely heavily on its industries as the driver for economic growth. As the engine of economic growth, technology will play an increasingly important role in nations' ability to prosper and grow. Technological innovation is the mechanism through which technology can be leveraged to create wealth and contribute towards a better quality of life.

Innovation - the introduction of new and/or improvement of products, services and production processes - is the driving force of a nation's economic development and the improvement of competitiveness of its firms (Freeman, 1986; Porter, 1990). In South Africa, there is a growing awareness, not only among entrepreneurs, but also among policy makers and scientists, that innovation should be in the centre of attention of business and policy strategies. In order to formulate such strategies and policies, it is important that there is a clear picture of the economic and innovative performance of South African companies.

Existing data sources, such as national R&D surveys, are widely recognised as being inadequate to develop policy and support analysis in the area of innovation. As a result, a number of countries, including South Africa, have recently begun to measure innovation more broadly. Of particular relevance are the European Community Innovation Survey and the 1996 Survey of Innovation in South African Manufacturing Firms.

The European Union (EU) has initiated regular innovation surveys in the member countries. The European Community Innovation Survey (CIS) is a standardised survey focusing, among others, on R&D investment, training efforts, technical personnel, new product development, and market success of new products. The CIS was jointly initiated and implemented by Eurostat and DG XIII under the aegis of the European Innovation Monitoring System part of the Innovation Programme. It was developed between 1991 and 1993 in co-operation with independent experts and the OECD. Based on the 'OECD Guidelines for collecting and interpreting data on technological innovation – 'the Oslo manual', a common questionnaire was developed.

The objective of CIS is to collect firm-level data on inputs to, and outputs of, the innovation process across a wide range of industries and across Member States and regions, and to use this data in high-quality analyses. This will contribute to the future development of policies for innovation and the diffusion of new technologies at Community, Member State and regional level.

CIS has three main characteristics. First, there had never before been internationally comparable data on non-R&D resources devoted to innovation and the output of the innovation processes. Second, it was the first time that a harmonised business survey had been implemented in all EU Member States. Third, the harmonised survey will not only give policy makers and analysts' information on the sectoral level, but also give them

a detailed picture of innovation activities at the level of European enterprises and EU member states.

The First CIS provided a major new source of information on innovation at enterprise level gathered from around 40,000 firms in all EU Member States, Norway and Iceland. This constitutes a unique database on innovation, which already acts as a foundation stone for future work in the area of analysis of innovation from academic and policy-making perspectives. In 1997, the Second CIS was launched. A strict co-ordination of the work has been imposed in order to guarantee a high degree of comparability between countries. In 2001, CIS 3 was put into place.

The first national Survey of Innovation in South African Manufacturing Firms (SISAMF-1996) was a joint undertaking by the Directorate for Science and Technology Policy of the Foundation for Research Development (FRD), and the Industrial Strategy Project (ISP) based at the Development Policy Research Unit of the University of Cape Town. The SISAMF-1996 was modelled on the CIS carried out in EU countries. This survey had to be modified to suit the South African environment and cater for a relatively limited budget.

The SISAMF-1996 (like the CIS) dealt primarily with inputs and outputs of the innovation activities in companies. The SISAMF-1996 questionnaire dealt with the following issues:

- General information (enterprise structure, turnover, employment and innovation intent)
- Enterprise objectives of innovation (extension of product range, creation of new markets, lowering of production costs, etc.)
- Sources for innovation (internal sources, market/commercial sources, education/research establishments, and information sources.)
- Costs of innovation
- Recent innovations
- Impact of innovation activities (sales, exports, new products, etc.)
- R&D activity
- Factors hampering innovation (economic, enterprise, etc.)

The SISAMF-1996 found that only a handful of South African firms see innovation as the key and critical component of the life of a firm (FRD, 1997). The SISAMF-1996 gave only limited insight into the innovation and technology management processes within companies. The focus was mainly on inputs (costs, human resources, information, R&D) and outputs (new products, sales, exports) of the innovation process. The SISAMF-1996 therefore does not pronounce on the innovation effectiveness of the South African manufacturing industry nor was this benchmarked against overseas industries.

Another deficiency of the SISAMF-1996 was that the innovation (management) processes and methodologies employed by the industry were not investigated in depth. Very little insight was therefore obtained in this regard, making it difficult to identify weaknesses and the needs of the industry. This is not only true for SISAMF-1996 but also for CIS 2. Both surveys underspecify the throughput-part of the innovation process. They are mainly focussed at inputs and/or outputs. Both surveys have a bias towards firms with innovations, neglecting the fact that firms can have innovative activities but realise no product/service or process innovations. This can be e.g. the result of failure or termination of an innovation project. The point we make is that having resources is not enough. It is also the way firms use and manage these resources that determines innovative output.

As the SISAMF-1996 was conducted in 1996, a number of firms indicated that major decisions concerning investments and production were on hold during 1996 when the

economy was in the early stages of adjusting to the new political dispensation. It is expected that the current survey would reflect far more activity on the innovation front.

The University of Pretoria and Eindhoven University of Technology have taken cognisance of the increasing importance of technological innovation as a basis for competition and its determining role in international competitiveness. Both universities believe that it is important to direct a part of their research efforts to the study of technological innovation, because this is an active way to advance the knowledge and skills in the management and policy aspects of technological innovation. Without a strong and relevant academic research effort in technological innovation to support and sustain the national innovation strategy, the South African industry will be found wanting in the global competitive arena.

As a result of this line of reasoning both universities are involved in a joint research project that includes the South Africa Innovation Survey 2001 (SAIS 2001). The research project has three main goals:

1. To get a representative, nationwide overview of the innovative behaviour and performance of South African firms in manufacturing and services in the period 1998-2000;
2. To benchmark the innovative behaviour of South African firms with the innovative behaviour of firms located in the European Community.
3. To formulate policy recommendations for the key role players in the South African System of Innovation.

In order to be able to reach these goals, the following research question has been formulated for the SAIS 2001 research project:

To what extent did South African firms in manufacturing and services conduct innovative activities in the period 1998-2000? It is the aim of this report to answer this research question.

1.2 Theoretical framework and structure of the report

Empirical research should be grounded on a sound theoretical framework. In this section the theoretical framework that was used as the basis for the development of the research instrument (the SAIS 2001 questionnaire) will be discussed briefly. As the same time, the outlined theoretical framework will be the organising principle of this report.

In his paper, 'Interactions in knowledge systems: foundations, policy implications and empirical methods', Keith Smith (1995) discussed the differences between the characteristics of technological knowledge in neo-classical production theory and modern innovation theory. Understanding the implications of these differences is an important starting point for the theoretical framework used in this research project.

Neo-classical production theory is built on the idea that firms face a dual production decision. Firstly, they must decide what to produce. This decision is based on knowledge of possible rates of returns and possible product lines, and firms will (re)allocate capital among them looking for the highest returns. Secondly, firms must decide which production technique to use. Firms within an industry face a given and known set of production technologies and are assumed to have the competences to use all available production technologies. Armed with this knowledge, and with knowledge of present and future factor and product prices, firms are able to maximise profits. Technology is seen as knowledge, and firms are able to access knowledge in a relatively rapid and cost-free way. As a result of these assumptions, the technological aspects of production are relatively unproblematic.

Technological process innovation is also unproblematic in neo-classical production theory, both with respect to adaptation to already-existing technologies, and to exogenous-given new technologies. The theory is based on the idea of rapid substitution possibilities across choice sets in production. Firms are able to change to new production configurations as a reaction to environmental change, adjusting their production technologies to changed factor prices. In this approach, economic efficiency is based on flexibility, both at the macro level and at the firm level.

Neo-classical production theory rests on an implied and implicit form of technological knowledge with very specific characteristics. Smith (1995: 75) argues that in a neo-classical world, technological knowledge must have the following features in order for the production theory to hold:

- It is generic: An item of knowledge can be applied widely among firms and even among industries;
- It is codified: Transmitability implies that knowledge is written or otherwise recorded in fairly usable form;
- It is costlessly accessible: transmission costs are negligible, or firms are not faced with differential costs barriers to obtain knowledge and bringing it into production;
- It is context independent: firms have equal competences in transforming knowledge into production capabilities.

Modern innovation theory tends to emphasise quite different aspects of technological knowledge, and hence provides a different view on the issue of technological knowledge and innovation. Clearly all firms operate with some kind of technological knowledge base. This is not a unitary base, and it often consists of three areas of production-relevant knowledge, with different levels of specificity. Firstly, there is the general scientific knowledge base. This base is highly differentiated internally and of widely varying relevance for industrial production. Some fields, such as molecular biology, solid-state

physics or inorganic chemistry, have close relationships with important industrial sectors. In other words, this knowledge base often has close connections with science.

Secondly, there are knowledge bases at the level of the industry or product field. Industries often share particular scientific and technological parameters, understandings of technical functions, performance characteristics, use of materials and so on, of products. Thirdly, within these technological parameters, the knowledge bases of specific firms are highly localised. Most firms understand one or a few technologies well and they form the basis of their competitive position. The highly specific features of these knowledge bases are not only technical. It also concerns the way in which technical processes can be integrated with skills, production routines, use of equipment and so on. These knowledge bases may be informal and tacit, taking the form of skills embodied in individuals or in groups of cooperating individuals or organisations. The tacit and localised characteristics of firm-level knowledge imply that although individual firms may be highly competent in specific areas, this competence is limited. This means, firstly, that firm's innovation processes can be problematic when technological innovations ask for competences, which lie outside the area of competences of the firm. Secondly, that the ability to carry out search processes relevant to problems can also be limited. As a result, firms must be able to access and use knowledge from outside the area of the firm when creating technologies and technological innovations.

The above suggests that knowledge bases in modern innovation theory have characteristics, which are very different than those in neo-classical production theory. Such knowledge bases are (Smith, 1995: 80-81):

- Differentiated and multi-layered, consisting of articulated forms of different knowledge;
- Highly specific, organised around a relatively limited set of functions, which firms understand well;
- Cumulative, the development of these knowledge bases are costly search processes, through processes of learning and adaptation, in which firms build up experience with specific technologies;
- Internally systemic, being part of an overall production system which has many components. Technological innovation involves a wide array of activities, which must be organised and managed by the innovating firm;
- Interactive and externally systemic: technological innovation usually involves, either implicitly or explicitly, structured interaction between institutions, involving processes of mutual learning and knowledge and information exchange.

The economic network approach, especially as developed by Håkansson (1987, 1989, 1992, 1993) and Håkansson & Snehota (1995), provides us with a model to analyse technological innovation. The approach can be considered as a clear example of a modern innovation theory in which Smith's ideas can be recognised.

Håkansson's economic network model contains three main elements: actors, activities, and resources. *Actors* perform activities and possess or control resources. They have a certain, but limited, knowledge of the resources they use and the activities they perform. Their main goal is to increase their control of the network. Actors in networks can be studied at different levels, from individuals to groups of firms. Two main types of *activities* are distinguished in the network model: transformation and transaction activities. Both are related to resources because they change (transform) or exchange (transact) resources through the use of other resources. Transformation activities are performed by one actor and are characterized by the fact that a resource is improved by combining it with other resources (like in production or innovation). Transaction activities link the transformation activities of the different actors. These exchanges result in the development of economic (network) relations between actors. There are several types of *resources;* physical (machines, raw material, components), financial, and human (labour, knowledge,

relations). Furthermore, resources can be classified according to the degree of organizational control. In the case of internal resources the firm has a hierarchical control, i.e. they own the resources. External resource providers control external resources. As a consequence, resources are heterogeneous, i.e., their (economic) value depends on the other resources with which they are combined.

In analysing technological innovation, the heterogeneity of resources and resource mobilization are the key concepts. According to Håkansson (1993), the effects of heterogeneity are that knowledge and learning become important. How should the firm handle these heterogeneous resources? In answer to this question, Håkansson cites Alchian & Demsetz (1972) who stated "efficient production using heterogeneous resources is not a result of having better resources, but knowing more accurately the relative performance of these resources". In other words, it is not only necessary to have resources, but to know how to use them.

This knowledge can be acquired in two ways: internally and/or externally. Learning to use internal resources can be accomplished in several different ways, for example through R&D activities or learning by using or doing. The external mobilisation of resources can be labelled "learning by interacting" (Lundvall 1988: 362), i.e., firms can use the knowledge and experience of other economic actors.

In order to make use of external resources, firms need to exist within structures, which make these learning processes possible and efficient. According to Håkansson, economic networks produce these structures characterized by stability and variety. First, scarce external resources are more easily mobilized through stable relations with other economic actors. Second, stable relations in networks enable innovating firms to gather knowledge and to learn from other actors how to use heterogeneous resources innovatively and efficiently. Third, the stability of economic network relations provides a basis for variety. This variety offers new opportunities for innovation.

The economic network approach makes it clear that firms can supplement their innovation process by using external resources as well. They can also acquire knowledge through the use of their economic network relations. But Håkansson's model does not provide us with a clear picture of innovative activities in firms.

After this review of Håkansson's descriptive economic network model and its usefulness for analysing innovation some critical remarks are in order. These remarks allow us to partially reformulate the network model for our empirical purposes. Our comments are related to the lack of theoretical maturity of the economic network approach in general and of Håkansson's network model in particular. Two problems will be addressed: the conceptualisation of innovation in the economic network model and classification of heterogeneous resources.

Håkansson overemphasises an inter-organisational approach to organizational processes. As a consequence, even innovation processes are primarily conceptualised as a product of external factors and interaction. In our view, innovation in firms is primarily internal in nature. External (f)actors can play a role in this process (see e.g., Von Hippel, 1988), but the innovator initially uses his internal capabilities. If the process runs into problems, external resources are sought (Oerlemans, 1996). We therefore have to find a balance between an internal and external view of innovation.

As Dosi stated (1988), "agents will plausibly allocate resources to the exploration and development of new products and new techniques of production if they know, or believe in, the existence of some sort of yet unexploited scientific and technical opportunities; if they expect that there will be a market for their new products and processes; and finally,

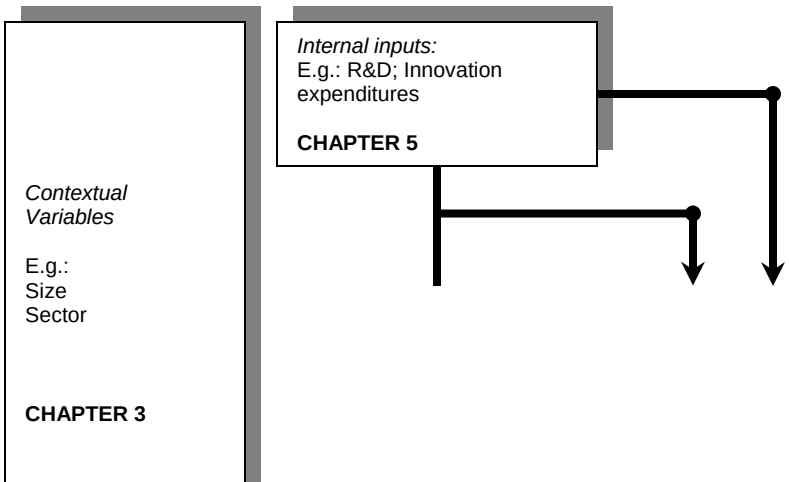
if they expect some economic benefit". Dosi stresses the knowledge, beliefs, and expectations of the innovating actor.

As a consequence, we have to define the technological innovation processes in Håkanssonian terms. Technological innovation is a *transformation* activity where an *actor,* through the (re)combination of heterogeneous *resources,* develops and introduces new or improved products/services or production processes with the expectation of better economic performance. Within firms, innovation is conceptualised as an open system (Katz and Kahn, 1966) where inputs (heterogeneous resources) are transformed (throughput) into outputs (results of innovations). This process is related to several economic actors, which, through their transformation and transaction activities, use resources in order to produce innovations.

Despite Håkansson's claim that resources are heterogeneous, and internal and external, he does not systematically identify which heterogeneous resource bases he is referring to. If we assume that innovation is a knowledge-intensive process, we must determine which knowledge bases (Dosi, 1988: 1126) can be used by innovators. As we have seen, Smith (1995) systematises the attributes of, what he calls, a 'modern view' on technological knowledge and innovation. The fact that resource bases of industrial firms are multi-layered has two important consequences for Håkansson's economic network model. Firstly, it means that although individual innovating firms are competent in specific areas, their competence is nonetheless limited. In other words, innovating firms use their specific resources to innovate but they can easily run into problems related to their innovation processes. The solution to these problems may lie outside their area of expertise. Therefore, they must be able to access and use external knowledge. Secondly, the multi-layered and heterogeneous nature of resource bases makes it necessary to distinguish several actors and institutions inside and outside the firm in which resources are embodied.

Internal resources are embodied in the transformation (e.g. R&D, production or engineering) and transaction functions (purchase, marketing/sales) of the firm. Outside the firm, at least four groups of actors can be distinguished: the public and private knowledge infrastructure, the production column and intermediaries. The public knowledge infrastructure consists of organizations such as universities and colleges for professional and vocational training. Trade organizations and consultants can be found in the private knowledge infrastructure. The technological knowledge found here is mainly related to the industry or product field. The same is true for the third group, the production column. Suppliers, buyers, and other firms such as competitors are grouped in this category. Intermediaries such as Chambers of Commerce and regional Innovation Centres can be seen as information brokers. They are able to give general and specific information on innovation related issues, but they are also able to bring parties into contact with each other.

All of the above enables us to formulate a research model, which can be used as a basis for the development of our research instrument.



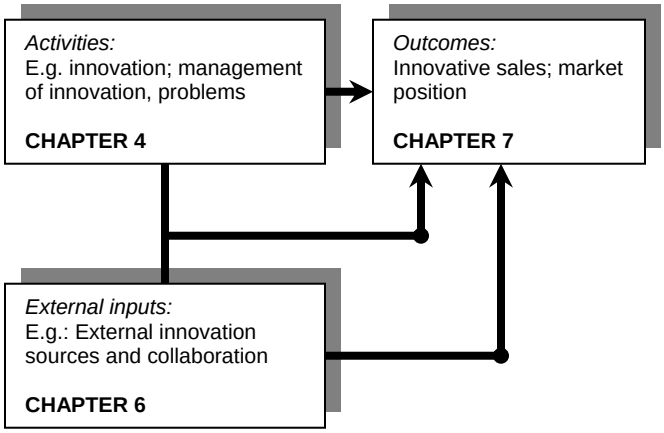


Figure 1.1: Research model

The research model as depicted in Figure 1.1, determines to a large extent the structure of this report:

- After this introductory chapter, Chapter 2 will deal with the SAIS 2001 survey design. The chapter discusses the population and sampling frame, the way in which data was collected and how the survey results were weighted in order to derive figures that can be applied to all South African firms in manufacturing and services.
- Chapter 3 describes the main characteristics of South African firms. Topics that will be analysed in this chapter are for example employment and employment growth, sales and sales growth, and the export performance.
- Chapter 4 concentrates on the innovative activities of South African firms. How many firms did innovate in the period 1998-2000? What were the innovation objectives of these firms? Which factors hampered innovation? How was the innovation process managed? These and other related questions will be answered in this chapter.
- Chapter 5 researches the amount of internal resources that firms allocate to innovation. Topics discussed in this chapter are amongst other, the R&D effort of South African firms, the total innovation expenditures, and the use and importance of internal information sources.
- As was explained in this introduction, more and more innovating firms use external sources for innovation. External sources comprise external information sources and innovative partnership in South Africa and abroad. These will be analysed in Chapter 6.
- Firms innovate to maintain or improve their performance. Therefore, the outcomes of innovative activities are an important issue and will be researched in Chapter 7.
- Lastly, in Chapter 8 the most important findings will be summarised and main conclusions will be formulated.

2. The SAIS 2001 survey design

2.1 Introduction

In the previous chapter we formulated the goals of this research. The main aim of the research is to get a representative, nation wide overview of the innovative behaviour and performance of South African firms in manufacturing and services in the period 1998-2000. To get this nation wide overview, a survey of South African firms was carried out. A survey implies a large-scale observation of a population (here South African firms) as a whole, or, and that is what is usually done, observing a sample (a fraction) of the population. In this research a sample of South African firms was observed. In total 7039 selected firms were asked to fill in a questionnaire about their innovative activities in the period 1998-2000. Of those 7039 firms, 617 filled in the questionnaire. In this chapter, we first discuss the population we targeted, the sample of firms that were selected, and the sampling frame used to select and address the firms. Second, we discuss the fieldwork of the survey, the firms that responded, and we conclude with an examination of the firms that did not respond.

2.2 Population and sampling frame

In this section, the population and the sampling frame of the SAIS 2001 are discussed. The concept population refers to all possible cases, which are of interest for a study, and specifies four elements: content, units, extent, and time. In the case of the SAIS 2001, this *population* can be defined as:

All South African firms in manufacturing and services with 10 or more employees that conducted economic activities in the period 1998-2000.

The South African Innovation Survey 2001 (SAIS 2001) thus covered both the manufacturing and selected service industries. The economic activities covered by the SAIS 2001 are shown in Table 2.1

With the just formulated definition of the population, it is possible to construct a so-called *sampling frame*. A sampling frame is a listing of all the elements in a population and the actual sample is then drawn from this listing. Therefore, the adequacy of the sampling frame is crucial in determining the quality of the sample drawn from it. A preliminary investigation resulted in the choice of the Reedbase database (August 2000 version) as a sampling frame. This database contains 16,931 South African firms with a known number of employees. In a next section, some other features of this database will be described.

Table 2.1: Industrial sectors covered in the SAIS2001 survey.

SIC code	ECONOMIC ACTIVITY	COVERED IN SAIS2001
1	AGRICULTURE, HUNTING, FORESTRY AND FISHING	No
2	MINING AND QUARRYING	No
3	**MANUFACTURING**	**Yes**

4	ELECTRICITY, GAS AND WATER SUPPLY	No
5	CONSTRUCTION	No
61	**WHOLESALE AND COMMISSION TRADE**	**Yes**
62-64	RETAIL TRADE, HOTELS AND RESTAURANTS	No
7	**TRANSPORT, STORAGE AND COMMUNICATION**	**Yes**
81-83	**FINANCIAL INTERMEDIATION**	**Yes**
84-85	REAL ESTATE AND RENTING	No
86-88	**BUSINESS SERVICES**	**Yes**
9	COMMUNITY, SOCIAL AND PERSONAL SERVICES	No
10	PRIVATE HOUSEHOLD, EXTERRITORIAL ORGANISATIONS, REPRESENTATIVES OF FOREIGN GOVERNMENTS AND OTHER ACTIVITIES NOT ADEQUATELY DEFINED	No

2.3 Adjustment for coverage error

The Reedbase database is a commercial database; unfortunately public databases are not available. Since firms have to pay to be included in the Reedbase, it obviously will not cover the entire population. The Manufacturing Census 1996 (MC 1996) contains precise information about the distribution of the size groups of manufacturing firms in South Africa, and thus offers a way to assess possible coverage errors. When comparing the size distribution of the MC 1996 to the Reedbase size distribution (see Table 2.2), it becomes clear that the distributions differ. Smaller firms are underrepresented and larger firms are over-represented in the Reedbase. An explanation for this difference is the fact that firms have pay to be included combined with the possibility that for the different size groups the incentive to be included differs. For instance, for smaller firms the incentive to be included in the database will by and large be smaller, and hence it may be expected that smaller firms will be underrepresented in the Reedbase. ***To adjust for this coverage error, in the analyses presented in later chapters, the population figures of the MC 1996 are used to weigh the survey results***. Because we were not able to get information for the size distribution in the service sectors, we used the MC1996 size distribution to adjust the size distribution of the service firms in the Reedbase.

Table 2.2: Comparison between Census 1996 (manufacturing) and Reedbase (manufacturing)

Size classes	Census 1996	Reedbase
10-49	66%	43%
50-249	26%	38%
250-499	5%	8%
>499	3%	11%
Total	100%	100%

In SAIS 2001 *stratified sampling* was used as the sampling technique. In this sampling technique the population is divided into a number of sub populations, so called strata. For every stratum, a separate sample of firms is selected. The major reason to use a stratified sample is that, compared to more simple, straightforward sampling techniques, stratifying can have the effect of reducing sampling error. This implies that anything we can infer about innovation in South Africa on the basis of this survey, can be stated with somewhat more confidence, then when more simple sampling techniques would have been used. For the SAIS 2001 the population of South African firms is divided into three different *size classes*.[1] Taking the number of employees as an indication of the size of a firm, the following three strata were distinguished:

- Stratum 1: firms with 11 to 20 employees;
- Stratum 2: 21-50 employees;
- Stratum 3: more than 50 employees.

[1] *We follow the sample design of the European CIS. The CIS has proven to be a useful design. Moreover, making designs similar enhances comparability of the SAIS with the CIS.*

There are at least two reasons for using size as the 'stratification variable'.[2] At first there is a theoretical reason. It is well known that innovative efforts differ considerably between size classes (Kleinknecht, Reijnen & Verweij, 1990; Brouwer and Kleinknecht, 1994). Second, there is a practical reason: the number of employees is the only quantitative variable in the South African Reed database. This is a necessary condition to compute strata size, so it is inevitable to use this variable.

Three sample frames were drawn from the Reedbase database. A sample frame is a list of firms from which the firms are selected. In this sample frames producers, distributors, and service firms were divided into three groups according to the formulated size classes. Table 2.3 describes some features of the three strata.

Table 2.3: Stratum size, mean, standard deviation and variance

Stratum	Number of firms	Mean number of employees
11-20 employees	2166	15.99
21-50 employees	4611	35.04
More than 50	3665	769.59

The number of firms that should be selected from each stratum is an important issue. Among the considerations about stratum sample size, the level of precision and the homogeneity of the population are important. For specific details about the calculations we refer to Oerlemans, Buys & Pretorius (2001). In Table 2.4 the sample size is shown. To enhance comparability with the European CIS it was decided to include all of the larger firms (stratum n_3) in the sample.

For the SAIS 2001, firms were randomly drawn[3] from the sampling frame (Reedbase) in the following way using size classes as strata:

- Firms in manufacturing and services with 50 employees and more are all included in the sample;
- Firms in manufacturing and services with 10–19 employees and 20–49 were randomly sampled according to the proportion in the sample frame.

Table 2.4: Sample size SAIS 2001

Stratum	N_i	n_i	Exp. Res. rate	Sample size
n_1	2,166	384	50%	768
n_2	4,661	1,824	70%	2,606
n_3	3,665	3,665	n.a.	3,665
Total	10,492	5,873		7,039

n.a. = not applicable

2.4 Data collection and response

The survey project started in June 2000. The second half of the year 2000 was used to develop a research design and instrument that were based on the European Community Innovation Survey but adapted to the South African context and the wishes of the research team. This research design was presented to an audience of scientists and

[2] *An attempt was made to include sectors as a stratification variable, but the classification of firms in the different sectors proved to be difficult, the sectors had considerable 'overlap'. For purposes of statistical estimation it is a prerequisite that in stratified sampling a firm can only be classified in one stratum.*

[3] *The Reedbase database has a software algorithm build in that enables random sampling from the database.*

practitioners at the joint South Africa / OECD seminar on Innovation Measurement, held in Pretoria at the end of March 2001.

In May 2001, a draft version of the research instrument, that is the questionnaire, was mailed to 15 selected South African companies in manufacturing and services as a pre-test of the usability of the research instrument. The feedback collected at the Innovation Measurement seminar and through the selected companies was used to adjust the questionnaire on a few minor points.

In close cooperation with the Telematics Education Department of the University of Pretoria, an electronic web-based questionnaire was developed in the period June to November 2001. This web-based questionnaire was used for on-line data entry purposes by a number of responding firms and by the research team itselves.

The actual data collection process started in December 2001, when about 7,000 paper questionnaires (see Annex A) were mailed to sampled South African firms in manufacturing and services. The questionnaire was sent to the managing directors of the sampled firms. A letter of introduction by the research team and a letter of recommendation written by Dr. B.S. Ngunabe, Minister of the Department of Arts, Culture, Science and Technology, Republic of South Africa, accompanied it. Firms were asked to complete the questionnaire and use the enclosed stamped addressed envelope.

In May 2002, the research team decided to change the data collection strategy because too few completed questionnaires came in. Therefore, the postal surveying process was ended and a strategy of direct surveying by telephonic interviews and e-mail was implemented. Research assistants did the actual surveying.

The effort of the SAIS 2001 research team resulted in a response, which is shown in Table 2.5. This table also shows a comparison between the response and sample. A total of 617 firms of the 7339 in the sample filled in the questionnaire. The percentage of firms that responded is thus 8.4%. If we look at the response divided into size classes, we see that small firms are somewhat underrepresented in the response.

Table 2.5: Size classes (employment 2000), Comparison of distributions of response and sample

Size class	Frequency Response	Percent Response	Percent Sample	Difference
< 50 employees	226	36.7	42.7	-6.0
50 to 250 employees	234	38.0	37.9	+0.1
250 to 500 employees	62	10.1	8.3	+1.8
500 and more employees	94	15.3	11.1	+4.2
Total	616	100.0	100.0	
Missing	1		0.0	
Total	617		(n=7339)	

In the South African Innovation Survey 2001, the following sector classifications were used (see Table 2.6), which is in line with the Standard Industrial Classification (SIC) system used for official South African statistics and the NACE industrial classification system used in the European Union.

Table 2.6: Sector classifications

SIC code	NACE code	Description of sector	Reedbase code	Response
30	15-16	Manufacture of food products, beverages and tobacco products	20, 21	36
31	17-19	Manufacture of textiles, clothing and leather goods	22, 23, 24	35
32	20-22	Manufacture of wood products, paper products, publishing and printing	25, 27, 28	21

33-34	23-26	Manufacture of fuel, chemicals, rubber, plastic and other non-metallic mineral products	29, 30, 31, 32, 33	92
35	27-30	Manufacture of metal products, machinery and equipment	34, 35, 36, 48, 40, 41, 42, 43, 44, 45, 46, 47, 51	130
36-37	31-33	Manufacture of electrical and optical equipment	37, 38	35
38	34-35	Manufacture of transport equipment	39	44
39	36-39	Manufacture of furniture; manufacturing n.e.c. and recycling	26, 49	26
60-61	50-51	Wholesale trade and commission trade	61, 62, 63, 64, 65, 66, 67, 68	107
71-75	60-64	Transport and Communication	72, 74, 75, 79	21
80-83	65-67	Financial Intermediation	82	17
86-88	72-74	Business services	44, 84	49
		Total		613

2.5 Non-response survey

In absolute numbers the response (617 responding firms) is reasonably high. However the proportion of firms that responded and returned the questionnaire is rather low, 8.4% of the firms in our sample responded. A low response rate is a rather common phenomenon in organizational research, and does not necessarily need to pose problems. However, if the firms that responded differ with respect to innovation from the firms that did not respond, then generalizing the results of this research to the South African business world as a whole becomes complicated. To assess whether the response differed from the non-response group, a non-response survey was carried out. Two considerations played a role in the design of this study. First, information should be collected among a considerable number of non-responding firms; otherwise results can be attributed too easily to chance.

To calculate the size of the non-response sample, we used the following procedure. In the non-response survey of the Dutch CIS 1992 (1994), a sample of 462 firms were randomly selected from the non-response group, which was about 5% of the gross sample size. If we apply this percentage to the SAIS 2001 non-respondent sample, this would mean about 320 non-respondents should be included. Table 2.7 shows the results.

Table 2.7: Determining the size of the non-response sample

Stratum	Sample size	Respondents	Non-respondents	Non respondents sample size
< 20 employees	768	87	681	35
20-50 employees	2606	137	2469	123
>50 employees	3665	380	3285	164
Total	7039	604	6435	322

Second, for a *non-response* survey it is critical that a very high percentage of firms respond. The non-response survey was conducted in the period August-October 2002. Considerable effort was put in to enhance the likelihood that firms participated in the non-response survey. The selected firms were called by telephone by research assistants. The respondents/informants were ensured that this research would not take much time, and that the participation of the respondents was extremely important to the success of the whole project (see Annex B for the non-response questionnaire). Almost all respondents that were contacted participated in this part of the study. The target of the non-response firms was 322. In total 416 firms responded, which is a response rate of 129%.

Table 2.8: Reasons for not responding to the SAIS 2001 survey

Reasons mentioned for not responding (More than one answer possible)	Number of times reason was mentioned	Percentage of non responding firms that gave reason
Did not receive questionnaire	215	52
I never fill in questionnaires	11	3
No use for the company	20	5
Lack of time	137	33
Other reasons	33	7

After the researcher introduced the study and him/herself, and the respondent agreed to answer some questions, the researcher asked the respondent about his/her reason(s) not to fill in the questionnaire. Table 2.8 shows the frequency in which four possible answers were given. More than half of the questionnaires were, according to the respondents, not received. A possible explanation is that questionnaires were mailed to the managing directors of the firms; however, the persons interviewed for this non-

response survey often were not managing directors, but others, and hence had not seen/received the questionnaire. Lack of time was mentioned as a major reason for not filling in the questionnaire. Other reasons mentioned included: problems with the possibility to fill in the questionnaire on the Internet (10 times), on leave (5 times), and a few respondents mentioned that they filled in the questionnaire and returned it (3 times).

To check whether our sample is biased because of the relatively high non-response rate, two questions were asked about the technological innovative activities of the non-responding firms. Ideally, we wanted to know more about the non-responding firms, but then the interview might take too much time. Because of this, respondents might quit the interview. We chose questions on innovation, because of its crucial importance for this research.

Table 2.9: The continuity of R&D activities for the response and the non-response group

Continuity of R&D	Response group	Non response group
More or less continuously R&D	196 (37%)	164 (40%)
Occasionally R&D	154 (29%)	119 (29%)
Not conducting R&D	178 (34%)	132 (31%)
Total	528	415

The first question of comparison was about the continuity of Research and Development activities in responding and non-responding firms. As can be observed in Table 2.9, the response and the non-response group do hardly differ in this respect. A statistical test (Mann-Whitney U-test) revealed that it could be assumed that the two groups are equal with respect to the continuity of their R&D activities (p=0.46).

Table 2.10: Technological innovation of the response and the non-response group

Technological innovations between 1998-2000	Response group	Non-response group
Yes	319 (54%)	241 (58%)
No	277 (46%)	175 (42%)
Total	596 (100%)	416 (100%)

The second question with respect to technological innovation of the non-responding firms was whether or not the firm had technological innovations in the period 1998-2000. Table 2.10 shows that the non-response group contains more (58%) innovators than the response group (54%), however, this difference is not statistically significant (z=1.4, p=0.17).

2.6 Conclusion

The aim of this chapter was to explain how the survey was designed. After implementing the design, a response rate of 8.4% was achieved. The survey of non-responding firms was to check whether the response group was biased, or to put it differently to check whether the sample of firms that responded and returned the questionnaire represents the population of South African firms. It was already noted that in the response group small firms were somewhat underrepresented (a statistically significant difference). However, there is no clear indication that the sample differs from the population on a number of crucial variables indicating innovativeness. Hence, we expect, also because survey results were weighted by the MC 1996 population figures, that the findings presented in the following chapters would accurately describe innovation and innovative activities of South African business life.

3. MAIN CHARACTERISTICS OF FIRMS

3.1 Introduction

South Africa has been described as a technology colony (De Wet, 2001). Technology colonies are countries whose industries are dependent on foreign technology because their National Systems of Innovation are deficient or poorly developed. The levels of economic activity in such colonies are concentrated at the production, supply, distribution, marketing and sales end of product / service life cycles. A relative small level of activity in the research end of the life cycle may be present, but an insignificant flow of technology from the local community to the local industrial sector takes place. It can thus be expected from this research that firms will show a high involvement in the marketing, distribution and sales of products and services, and that the involvement of firms in the production of products and/or the supply of services will also be high. Because of the smaller activities in research in the technology colony countries, it can also be expected that foreign sources of technology will be higher for the South African industry than in developed economies. Higher sales will thus be accompanied by low product and services development activities.

This chapter has two aims. The first aim is to describe the main characteristics of South African firms. Second, to find out whether South Africa has the characteristics of a technology colony. To reach objectives, the main activities of firms, employment, sales and exports, and various other firm characteristics are reported.

3.2 Enterprise structure

In this section, some dimensions of the enterprise structure of South African firms in manufacturing and services are described. The main economic activities, employment, turnover, exports, and the establishment of new firms will be analysed successively.

3.2.1 Main economic activities

To get an overview of the main economic activities of South African firms, they were asked to indicate the economic activity in which the highest percentage of sales was realized as the criterion. About 58% of all firms were manufacturing firms, 23% were service providers, and 19% were wholesale businesses.

A more detailed picture of main economic activities of firms is shown in Table 3.1. The production of product parts and components (24% of firms) and consumer goods (also 24% of firms) accounts for almost half of all economic activities that firms were engaged in. However, many firms had activities in more than one area.

Table 3.1: Main economic activities of firms

Main activities	Percentage of firms.
Production of consumer goods	24
Production of raw and refined materials	9
Production of product parts and components	24
Production of production equipment	7
Wholesale business in consumer goods	11
Wholesale business in raw and refined materials	4
Wholesale business in product parts and components	8
Wholesale business in production equipment	4
Provision of transport services	3
Provision of communication services	2
Provision of financial services	2
Provision of business services (engineering, IT services, etc.)	6
Other	21

About 43% of the firms indicated that their financial results were annually consolidated with those of subsidiaries and/or holding company. Approximately 26% of the firms were indirectly affiliated to other firms (e.g. in a franchise agreement, etc.), whereas 88% of the firms' head offices are located in South Africa.

3.2.2 Employment 2000 and employment growth 1998-2000

Firms were asked to indicate how many people they employed in 1998 and 2000, respectively. In Table 3.2, the distribution of firms in different size classes in 2000 is presented.

Table 3.2: Employment 2000, by size class

Size class 2000	Percentage
< 50 employees	71
50 to 250 employees	22
250 to 500 employees	4
500 employees or more	3
Total	100

The majority of firms (71%) can be classified as small firms, that is, they employ less than 50 employees. Another 22% of firms have between 50 and 250 employees, whereas about 7% of the firms employ 250 or more workers.

Using the 1998 and 2000 employment figures, it is possible to calculate the average growth percentage of employment in the period 1998-2000 for all firms, per sector, and per size class. First, the average growth percentages of employment for all firms and per sector are presented (see Table 3.3).

Table 3.3: Average growth percentage of employment 1998-2000, by sector

Sector	Average growth % employment 1998-2000
Manufacturing of food, beverages & tobacco	-12.1
Manufacturing of textiles, clothing & leather products	-0.3
Manufacturing of wood and paper (products) & publishing	-1.9
Manufacturing of chemicals, rubber and plastic products	-5.8
Manufacturing of metal product, machinery, and equipment	-15.3
Manufacturing of electrical & optical equipment	-10.2
Manufacturing of transport equipment	-2.5
Manufacturing of furniture, and n.e.c.	+6.4
Wholesale	-5.4
Transport and communication	-9.3
Financial intermediation	+2.3
Business services	+40.5
Total	-6.9

Total employment decreased with almost 7% during the period 1998 – 2000, which means about –2.3% per year in this period. This finding is in agreement with published employment statistics. According to statistics from the Department of Trade and Industry (DTI, 2002) the manufacturing sector had 1,350,784 employees in 1998 and 1,296,166 employees in 2000, a decline of 4%. According to Statistics South Africa (STATSSA, 2001b), total employment in the transport, storage and communication sector changed from 246,000 (1998) to 222,000 (2000), a decline of 10%. In this research, the estimated decline of employment for this sector in the same period was –9.3%.

As can be concluded from Table 3.3, sectors can be categorised into three groups: sectors with a negative growth of employment, with a positive growth of employment, and sectors that nearly stabilised their employment in the period 1998-2000. Examples of the first group are the metal products, machinery & equipment industry (-15.3%), the food, beverages & tobacco industry (-12.1%), and the manufacturing of electrical and optical equipment (-10.2%). Employment growth was only observed in three sectors: business services (+40.5%, i.e., about 14% per year), the manufacturing of furniture and other manufacturing sector (+6.4%), and financial intermediation (+2.3%). A more or less unchanged employment volume was noted for the textiles & leather products industry (-0.1% per year), and the wood and paper (products), printing & publishing industry (-0.6% per year).

Did the different size classes contribute to the same extent to this decrease of employment between 1998 and 2000? This question can be answered with the figures presented in Table 3.4. Major downsizing of employment occurred predominantly in the large organisations with more than 500 employees. Between 1998 and 2000, a negative growth of 9.3% was observed. With the exception of the size class 250 to 500 employees, firms in other size classes lost jobs too.

Table 3.4: Average growth percentage of employment 1998-2000, by size class

Size class	Average growth % employment 1998-2000
< 50 employees	-4.2
50 to 250 employees	-2.2
250 to 500 employees	+1.9
> 500 employees	-9.3

3.2.3 Sales 2000 and sales growth 1998-2000

In Table 3.5, the sales volumes of South African firms are presented. As can be concluded from the Table, the population represents a mix of small, medium-sized and large organisations.

Table 3.5: Sales 2000

Sales class	Percentage of firms	Cumulative Percent
Less than R1 million	4.6	4.6
R1 to R2 million	5.2	9.8
R2 to R4 million	10.4	20.2
R4 to R6 million	9.6	29.8
R6 to R10 million	13.1	42.9
R10 to R15 million	13.6	56.5
R15 to R20 million	6.1	62.6
R20 to R40 million	14.3	76.9
R40 to R80 million	9.7	86.6
R80 million or more	13.4	100.0
Total	100.0	

About 43% of the firms generated a maximum of R10 million in 2000, whereas another 20% had sales volumes between R10 and R20 million. Large firms in term of sales (R80 or more) count for about 13% of the total.

The mean total sales of firms increased from R147 million per firm in 1998 to R157 million per firm in 2000. The 50 to 250 employees size class had a decline in sales from R389 million per firm in 1998 to R366 million per firm in 2000 as shown in Table 3.6.

Table 3.6: Total sales in 1998 and 2000, by size class

Size class	Mean total sales per firm.	
	1998	2000
< 50 employees	R12.0 million	R14.6 million
50 to 250 employees	R389.3 million	R365.8 million
250 to 500 employees	R158.3 million	R198.7 million
> 500 employees	R1,299.0 million	R1,655.0 million

The average annual growth percentage of sales between 1998 and 2000 of all firms was 2.3% in nominal terms (not deflated). An overview of mean annual sales growth of all firms per sector is presented in Table 3.7.

Table 3.7: Average annual growth percentage of sales 1998-2000 (not deflated), by sector

Sectors	Average annual growth % Sales 1998-2000
Manufacturing of food, beverages & tobacco	+6.5%
Manufacturing of textiles, clothing & leather products	+16.9%
Manufacturing of wood and paper (products), printing & publishing	+9.0%
Manufacturing of chemicals, rubber and plastic products	+11.3%
Manufacturing of metal product, machinery & equipment	+9.1%
Manufacturing of electrical and optical equipment	+7.4%
Manufacturing of transport equipment	+11.3%
Manufacturing of furniture, and n.e.c.	+15.4%
Wholesale	-2.7%
Transport and communication	+20.6%
Financial intermediation	+3.9%
Business services	+8.3%
Total	+2.3%

All South African sectors show a positive average annual growth of sales between 1998 and 2000, with the exception of the wholesale sector. Since there are a high number of firms with a negative growth in this sector, it influences the figure for the population substantially. The strongest growth was observed for the transport and communication sector (+20.6%), followed by the manufacturing of textiles, clothing & leather products. Third in row were the manufacturing of furniture & other manufacturing (+15.4%). Slow growth could be noted for financial intermediation (+3.9% annually) and the food industry (+6.5%).

Table 3.8: Average growth percentage of sales 1998-2000, by size class

Size class	Average growth % sales 1998-2000
< 50 employees	21.3%
50 to 250 employees	-5.6%
250 to 500 employees	27.6%
> 500 employees	27.4%

Growth rates for every size class in the period 1998-2000 between 20 and 30%. The only exception is the size class 50 to 250 employees, which experienced a negative growth rate (-5.6%). This is a confirmation of an earlier finding, since average sales per firm showed the same tendency.

3.2.4 Exports 2000 and export growth 1998-2000

The export ratio of a firm gives a good indication of the way an organization is performing on international markets. Of course, not every product or service is suitable to trade on international markets, since some products are especially intended for domestic markets. Table 3.9 provides an insight in the export performance of South African firms. The export performance is measured as the sales volume sold to foreign countries as a fraction of total sales of a firm in 2000.

Table 3.9: Export ratio 2000

Export classes	Percentage of firms	Cumulative percentage
0%	37.7	37.7
1 to 10 %	31.7	69.4
10 to 20 %	8.3	77.7
20 to 30 %	7.1	84.8
30 to 40 %	2.5	87.3
40 to 50 %	1.9	89.2
50 to 60 %	2.1	91.3
60 to 70 %	2.1	93.4
70 % or more	6.6	100.0
Total	100.0	

As can be seen from the figures in the table, firms can be roughly divided into three groups. First, there is a group of firms that has no exports in 2000 (37.7%). Second, about 32% of all firms had a low export ratio, between 1% and 10% of their sales volume. Third, there is a group of firms with high export levels. About 9% of all firms sold more than 60% of their turnover in foreign countries. In Table 3.10, the mean export ratio 2000 of each sector is reported.

Table 3.10: Export ratio 2000, by sector

Sectors	Export ratio 2000
Manufacturing of food, beverages & tobacco	38.2%
Manufacturing of textiles, clothing & leather products	10.3%
Manufacturing of wood & paper (products), printing & publishing	11.2%
Manufacturing of chemicals, rubber and plastic products	10.8%
Manufacturing of metal product, machinery & equipment	13.6%
Manufacturing of electrical and optical equipment	20.8%
Manufacturing of transport equipment	15.6%
Manufacturing of furniture, and n.e.c.	7.5%
Wholesale	11.2%
Transport and communication	18.4%
Financial intermediation	12.4%
Business services	12.3%
Total	13.7%

Two groups of firms can be distinguished. Firms in the textiles, clothing & leather industry, the manufacturing of wood and paper (products), publishing & printing, the chemicals, rubber & plastic industry, manufacturing of furniture and wholesale sectors tend to have a relatively low export ratio, whereas firms in the food, beverages & tobacco, manufacture of electrical and optical equipment, transport and communication sectors have relative high export ratio levels, that is above the industry average.

Table 3.11: Change in export ratio 1998-2000, by sector

Sector	Export ratio 1998	Change 1998-2000
Manufacturing of food, beverages & tobacco	32.3%	+5.9
Manufacturing of textiles, clothing & leather products	8.7%	+1.6
Manufacturing of wood & paper (products), printing & publishing	8.9%	+2.3
Manufacturing of chemicals, rubber and plastic products	10.2%	+0.6
Manufacturing of metal product, machinery & equipment	10.7%	+2.9
Manufacturing of electrical and optical equipment	16.4%	+4.4
Manufacturing of transport equipment	14.9%	+0.7
Manufacturing of furniture, and n.e.c.	7.1%	+0.4
Wholesale	10.7%	+0.5
Transport and communication	19.9%	-1.5
Financial intermediation	12.4%	0.0
Business services	10.8%	+1.5
Total	12.1%	+1.6

The development of the export ratio of a company in a time period gives a good indication whether this organization maintains or improves its competitive position on international markets. In the survey, firms were asked to indicate their export ratios in two years: 1998 and 2000. In Table 3.11, these changes are depicted. Some interesting findings can be reported on the basis of the figures in this table. Firstly, the overall export ratio of South African firms in manufacturing and services increased with 1.6%-point in the period 1998-2000. With the exception of two sectors (transport & communication and financial intermediation), all sectors contributed to this increase. Secondly, sectors that had high export ratios in 1998 were able to realise the highest increases between 1998 and 2000. This is true for the food, beverages and tobacco industry (5.9%-points increase; number one South African exporting sector in both years) and the electrical & optical equipment industry (+4.4%-points increase, moved from third to second position). The manufacture of metal products, machinery & equipment can be considered as a runner-up. Firms in this sector realised an increase of their export ratio of almost +3%-points. As a result, the sector moved from rank 7 to rank 5 of sectors with the highest export ratios. The only sector that was not able to maintain its export position was transport & communication, which experienced a decrease of its export ratio of –1.5%-point.

Table 3.12: Exports ratio 1998 and 2000, by size class

Size class	Exports ratio in:		Change
	1998	2000	
< 50 employees	11.6%	12.5%	+0.9
50 to 250 employees	10.9%	13.5%	+2.6
250 to 500 employees	15.6%	20.8%	+5.2
> 500 employees	25.2%	28.5%	+3.3

As can be derived from Table 3.12, export ratio is size dependent. Larger firms tend to have higher export ratios in comparison to smaller firms. Moreover, every size class was able to improve its export ratio, but larger firms were able to generate higher increases. In other words, especially the larger South African firms contribute to the overall increase of the export ratio between 1998 and 2000.

3.3 Business activities

In the introduction of this chapter, the question was raised whether South Africa is as a technological colony. The findings reported in this section aim to measure the profile of

the business activities that firms are engaged in. This will shed some light on answering this question.

3.3.1 Marketing, distribution and sales

Firms were asked about their involvement in the marketing, distribution and sales of products and services. About 92% of South African firms indicated that they are involved in the activities of marketing, distribution and sales. The firms also were asked to indicate to what extent they are involved in the marketing, distribution and sales of their own products/services, products/services by local companies and/or imported products/services (Table 3.13).

Table 3.13: Involvement in marketing, distribution and sales of products/services

Origin of products/services:	% firms involved
Own products/services	73
Products/services by local suppliers	25
Imported products/services	31

About 73% of the firms were involved in the marketing, distribution and sales of own products or services. About one of every three firms marketed, distributed and sold imported products or services.

The differences between the sectors in terms of their marketing, distribution and sales activities are summarised in Table 3.14. The manufacturing sectors show a much higher involvement in own product/services marketing, distribution and sales activities than the service sectors. Most firms (99%) in the food, beverages & tobacco sector are involved in marketing, distribution and sales of their own products/services. The same is true for firms in the chemical industry, the electrical and optical equipment industry, the manufacture of transport equipment and the furniture industry. Only a few firms in the wood/paper/publishing and financial sectors are involved in the marketing, distribution and sales of locally supplied and imported product/services. Sectors with relatively high levels of marketing, distribution and sales of imported products are the electrical & optical equipment industry, the furniture industry, and the wholesale sector. The profiles for the services sectors differ quite a lot and can probably be explained by the nature of the business in that specific sector.

Table 3.14: Involvement in marketing, distribution and sales of products/services, by sector

Sectors	Own products/ services	Products/ services by local suppliers	Imported products/ services
Manufacturing of food, beverages & tobacco	99	10	15
Manufacturing of textiles, clothing & leather products	76	14	13
Manufacturing of wood & paper (products) and publishing	84	3	11
Manufacturing of chemicals, rubber and plastic products	91	9	17
Manufacturing of metal product, machinery & equipment	82	18	28
Manufacturing of electrical and optical equipment	90	21	38
Manufacturing of transport equipment	94	7	16
Manufacturing of furniture, and n.e.c.	92	14	35
Wholesale	42	65	65
Transport and communication	58	4	14
Financial intermediation	61	5	3
Business services	59	22	19
Total	73	25	31

3.3.2 Production

Firms were asked about their involvement in the production of products and/or the supply of services. About 81% of the firms indicated that they are involved in the production of products and/or the supply of services. Table 3.15 gives a breakdown of the percentage firms per size class that indicated their involvement in production of products and/or supply of services. It is clear that there are only minor variations between the size classes.

Table 3.15: Involvement in the production of products and/or the supply of services, by size class

Size class	% firms involved
< 50 employees	80
50 to 250 employees	85
250 to 500 employees	89
> 500 employees	87

Firms also could indicate the sources of their production technology (technical know-how and techniques). They were given three options namely in-house sources (propriety intellectual property), local sources (local organisations) or foreign sources (e.g. production licences). Obviously, more than one source of technology can be used. Table 3.16 gives a breakdown of the sources of technology by sector.

Table 3.16: Percentages of firms indicating sources of production technology, by sector

Sectors	In-house sources	Local sources	Foreign sources
Manufacturing of food, beverages & tobacco	66	36	24
Manufacturing of textiles, clothing & leather products	52	9	13
Manufacturing of wood & paper (products), printing & publishing	53	36	29
Manufacturing of chemicals, rubber and plastic products	79	23	25
Manufacturing of metal product, machinery & equipment	74	24	25
Manufacturing of electrical and optical equipment	75	15	22
Manufacturing of transport equipment	77	10	39
Manufacturing of furniture, and n.e.c.	76	36	10
Wholesale	19	22	10
Transport and communication	37	30	33
Financial intermediation	66	25	21
Business services	46	33	28
Total	57	24	22

Sectors having a high percentage of firms employing in-house production technologies are the food, beverages & tobacco industry, the chemical industry, the manufacturing of metal products, machinery & equipment, the electrical & optical equipment industry, the transport equipment industry and the furniture industry. Therefore, it can be concluded that especially manufacturing sectors use relatively often in-house production technologies, as compared to service sectors.

Sectors that rely to a relatively high extent (as compared to all South African firms) on local sources for their production technologies are the food, beverages & tobacco industry, the manufacturing of wood & paper (products), printing & publishing, the furniture industry and the business services sector.

Firms in the manufacturing of wood & paper (products), printing & publishing sector, the transport equipment industry (automotive), transport & communication sector (telecommunication), and the business services sector use often foreign sources for their production technologies. About 40% of firms in the transport equipment industry, and 33% of the firms in the transport and telecommunication sector use foreign sources.

Table 3.17: Percentages of firms using specific technology sources, by size class

Size class	In-house sources	Local sources	Foreign Sources
< 50 employees	52	25	19
50 to 250 employees	69	21	25
250 to 500 employees	66	18	33
> 500 employees	67	20	43
Total	57	24	22

An interesting observation (see Table 3.17) is that bigger firms tend to use more foreign technology sources than smaller firms. About 43% of firms with 500 employees or more use foreign sources, whereas 19% of small firms (< 50 employees) use these sources. Using foreign technology is relatively expensive. Since larger firms have more (financial) resources at their disposal, they will use foreign technology more frequently than smaller firms.

3.3.3 Transferring or selling technology

Firms were asked if they transferred or sold own technology to other firms. Technology can be sold in the form of production licences, patents, specifications, etc. Only 12% of the firms indicated that they do transfer or sell technology to other firms. Table 3.18 gives a breakdown of the percentage firms that transfer or sell technology to other firms per size class.

Table 3.18: Percentages of firms that transfer or sell technology to other firms, by size class

Size class	% of firms transferring or selling technology
< 50 employees	11
50 to 250 employees	12
250 to 500 employees	16
> 500 employees	25
Total	12

There is a clear trend that larger firms have a higher activity in transferring and selling technology. About one of every four large firms sells or transfers own technology to other firms.

Firms were also asked what type of technology they transfer or sell to other firms. The types of technology were classified in

- Marketing, distribution and sales technologies
- Production and process technologies
- Product technologies
- Technical know-how and techniques

Table 3.19 shows the percentages of firms that transfer or sell a specific type of technology to other firms per size class.

Table 3.19: Percentages of firms that transfer or sell a specific type of technology, by size class

Size class	Marketing, Distribution and sales technology	Production and process technology	Product technology	Technical know-how and techniques
< 50 employees	4	2	5	5
50 to 250 employees	2	6	6	7
250 to 500 employees	3	5	11	10
> 500 employees	4	17	13	17
Total	4	4	6	6

As can be derived from Table 3.19, it is especially production & process technologies and technical know-how & techniques, which are transferred or sold to other firms (by large firms). To a smaller extent, product technologies are transferred or sold, again mainly by larger firms.

Table 3.20 shows the percentages of firms per sector that transfer or sell a specific type of technology to other firms.

Table 3.20: Percentages of firms that transfer or sell a specific type of technology, by sector

Sectors	Marketing, Distribution and sales technology	Production and process technology	Product technology	Technical know-how and techniques
Manufacturing of food, beverages & tobacco	9	2	1	2
Manufacturing of textiles, clothing & leather products	0	2	0	3
Manufacturing of wood & paper (products) & publishing	9	0	9	0
Manufacturing of chemicals, rubber & plastic products	10	9	11	8
Manufacturing of metal product, machinery & equipment	3	5	6	7
Manufacturing of electrical and optical equipment	6	8	18	13
Manufacturing of transport equipment	2	3	2	3
Manufacturing of furniture, and n.e.c.	0	0	0	0
Wholesale	3	1	2	2
Transport and communication	0	0	2	4
Financial intermediation	1	1	0	0
Business services	0	1	9	17
Total	4	4	6	6

Between the manufacturing sectors, the electrical and optical equipment sector transferred and sold by far the most technical know-how/techniques and product technology. Between the services sectors, the business services sector has the highest activity in technology transfer and sales.

3.4 Summary and conclusions

Main economic activities

Using the economic activity in which the highest percentage of sales was realised as the criterion, it was found that about 58% of all firms were in manufacturing, whereas 23% were service providers and 19% of the firms were involved in wholesale activities. More specifically, about half of the firms are involved in the production of products parts & components and consumer goods.

Employment 2000 and employment growth 1998-2000

The majority of firms are small and medium-sized organisations. About 7% of the firms employed 250 or more employees in 2000. It was found that employment in the South African economic base contracted during the period 1998 to 2000. The number of employees declined by about 7%, but major downsizing occurred predominantly in the large organisations with more than 500 employees. They lost more than 9% of their workforce during this period. A decrease of employment was especially observed in the metal products industry, the food, beverages & tobacco industry and the manufacturing of electrical & optical equipment. Positive growth figures were observed in three sectors: business services, financial intermediaries, and manufacturing of furniture & other manufacturing.

Sales 2000 and sales growth 1998-2000

The mean total sales of firms increased from R147 million per firm in 1998 to R157 million per firm in 2000. The average annual growth percentage of sales from 1998 to 2000 of all firms was +2.3% in nominal terms (not deflated).

Export ratio 2000 and export ratio growth 1998-2000

About 70% of South African firms in manufacturing and services have no or low export ratio levels (0 to 10%). Approximately 11% of firms realised high export ratio levels, i.e., they exported 50% or more of their sales to foreign countries. Firms with high export ratios can especially be found in the food, beverages & tobacco industry, the electrical and optical equipment industry, and in the transport and communication sector. Exports as a percentage of total sales of firms increased with an average of 1.6%-point in the period 1998-2000. Larger firms had a higher percentage export sales than smaller firms and export growth was also more pronounced for larger firms.

Marketing, distribution and sales activities

About 73% of the firms were involved in the marketing, distribution and sales of own products or services. About one of every three firms marketed, distributed and sold imported, i.e. foreign, products and services. This last practice was especially observed in the electrical & optical equipment industry, the manufacturing of furniture and other manufacturing sector, and in the wholesale sector.

Production and the sources of production technologies

About 81% of the firms indicated that they were involved in the production of products and services. Some sectors, like the food, beverages & tobacco industry, the chemical industry and the electrical and optical equipment industry rely to a large extent on in-house sources for their production technologies. Some sectors, however, use foreign sources too. This was found for firms in the wood & paper (products), printing & publishing sector, the transport equipment industry, and the transport and communication sector. Mainly larger South African firms are heavy users of foreign sources of production technologies.

Transferring or selling technology

One of every ten South African firms in manufacturing and services transfers or sells own technology to other firms, which is typically an activity of the larger firms that transfer or sell production and process technology, and technical know-how and techniques.

Jobless growth

Notwithstanding the decrease in employment, sales and exports increased. South Africa was thus also experiencing the "jobless growth" phenomenon observed in many developed countries in Europe and the USA (Moore, 1995).

Technology colony?

The question whether the South African economy is a technology colony cannot be answered with a straightforward ‘yes’ or ‘no’. Clearly some findings point in that direction: a relatively high proportion of firms import products and services, use foreign sources of production technologies, whereas a relatively low percentage of firms sell or transfer own technologies to other firms. Notwithstanding these findings, sectoral variations are significant, which leads to the conclusion that some sectors display the characteristics of a technology colony, but other do not fit the model.

4. INNOVATIVE ACTIVITIES

4.1 Introduction

In this chapter, the focus is on innovative activities. Innovation is a core process of firms, and is about (technological) change. Technological changes in firms can take two forms: (1) innovation in the items a firm offers to the market, its products and/or services, and (2) innovation of the processes that a firm employs to create and deliver those products and services. So, two types of technological innovation can be distinguished: product/service and process innovations on the one hand, and innovation in a broader sense on the other hand. In this chapter, it will be examined to what degree South African firms and sectors innovated in the period 1998-2000, and if so whether these innovations were new or improved products/services or processes. Besides technological innovation, firms can also innovate in a broader sense. They can innovate their organisation, like business strategies, and marketing. In this chapter we will examine this broader, organisational innovation as well.

A characteristic of an innovation is its degree of novelty. The degree of novelty runs from minor, incremental improvements right through to more radical changes in which whole new concepts are implemented. Incremental improvements refer to step-by-step improvements of a product/service or process, for example the improvement of the engine of a car. Radical changes refer to more drastic changes, like for example a totally new concept of an electric car. Below it will be examined whether changes in products/services and processes were 'step-by-step' or 'drastic'.

Innovative activities are increasingly outsourced and managed in co-operation with third parties. This is in part the result of the fact that given the increase in the complexity of many products and services firms cannot innovate in isolation, therefore it makes sense to collaborate with third parties. Secondly, there is a division of labour effect. Firms question their core competencies and purposes, with the result that non-core innovations are increasingly outsourced to third parties. In this chapter, it will be researched whether innovations were 'purchased', 'created together with third parties', or 'created by firms on their own'.

Innovation can be a risky, uncertain and costly business, and hence innovation activities do not automatically lead to success. There are many examples of promising innovation projects that were terminated, seriously delayed or were otherwise problematic. For most firms, innovation is a partial success but with problems (Tidd, Bessant & Pavitt, 2001). Factors that hamper innovation may provide good starting points for technology management and policy interventions. In this chapter, factors that may hamper innovation will be discussed. A closer look will be given at reasons why firms did not start innovation projects, and besides that, bottlenecks hampering innovation projects will be investigated.

Technology management plays a very important role in achieving the goals of a firm. Technology management embodies the (implicit) plans companies make to effectively develop, acquire, and deploy technological resources in a way to ensure an integrated business and technology vision that leads to a better performance (Zahra, 1996). In

section 4.5 of this chapter, the focus is on the technology management practices of South African firms, which indicated that they have innovative activities

4.2 Innovative Activities

4.2.1 Technological innovative activity

In this section, the focus is on technological innovations. About 44% of the South African firms had technological innovations in the period 1998-2000. This percentage is somewhat lower than the percentage of innovating firms in the European Union (Eurostat, 2000), which is about 51 percent.

Table 4.1: Percentages of firms with technological innovations in the period 1998-2000, by sector

Sectors	Technological innovations in 1998-2000
Manufacturing of food, beverages & tobacco	36
Manufacturing of textiles, clothing & leather products	28
Manufacturing of wood & paper (products), publishing and printing	35
Manufacturing of chemicals, rubber and plastic products	54
Manufacturing of metal products, machinery, and equipment	53
Manufacturing of electrical and optical equipment	80
Manufacturing of transport equipment	70
Manufacturing of furniture, and n.e.c.	43
Wholesale	21
Transport and communication	37
Financial intermediation	29
Business services	49
Total	44

As was already noted by Pavitt (1984), there can be strong sectoral variations in the rate of innovation depending on firm size, type of products, and the way firms organise their knowledge production and use. As can be observed from table 4.1 there are large variations between sectors in the percentage of firms that had technological innovations. Most technological innovations occurred in the sectors manufacturing of electrical and optical equipment (80% of the firms), manufacturing of transport equipment (70%), manufacturing of chemicals, rubber & plastics (54%), the manufacturing of metal products, machinery & equipment (53%), and the service sector business services (49%). The least technological innovations occurred in the sectors wholesale (79% of the firms in this service sector had no technological innovations), manufacturing of textiles, clothing & leather products (72%), financial intermediation (71%), manufacturing of wood, paper & publishing (65%), and manufacturing of food, beverages & tobacco (64%).

Table 4.2: Technological innovations in the period 1998-2000, by size class

Size Classes	Technological innovations in 1998-2000?
< 50 employees	38
50 to 250 employees	57
250 to 500 employees	62
> 500 employees	77
Total	44

Table 4.2 shows that large firms most often reported technological innovations (77%). The percentage of small firms that reported technological innovations is much lower (38%). This apparent relationship between size and innovativeness is in line with the

supposition of, among others, Schumpeter (1983), that innovation is a matter of size. The reason for this relation is mainly because large firms have more resources, and profit more from economies of scale in innovation processes and projects.

4.2.2 Innovation in a broader sense

Besides innovating technical products, services or processes, firms can also innovate in a broader sense; they can for example improve their business strategies. To get an impression of the rate of innovation in a broader sense firms were asked to indicate whether they undertook the following activities: reflection on and/or change of (long term) strategic goals of the firm; development of new marketing concepts and/or aesthetic change of product design; implementation of radical change of the organisation of the firm; and implementing new management tools. Most South African firms changed their business strategy (62%), and marketing (50%) in the period 1998-2000. The firms changed their organisation (36%), and management (36%) to a somewhat lesser extent. However, in general large and medium sized firms are more likely to reorganise and change management than smaller firms.

Table 4.3: Percentages of firms with Innovation in a broader sense, by size class

Size Classes	Innovative activities in 1998-2000			
	Business strategy	Marketing/design	Reorganisation	Management
< 50 employees	55	47	29	27
50 to 250 employees	77	58	47	54
250 to 500 employees	78	59	60	62
> 500 employees	87	63	66	63
Total	62	50	36	36

4.2.3 Innovated products and/or services

Two types of technological innovations can be distinguished: product/service innovations, and process innovations. In this section, we focus on product/service innovations. Firms were asked to indicate whether they introduced products and/or services to the market in the period 1998-2000, which were technologically improved or new.

Table 4.4: Percentage of firms with innovated products and/or services 1998-2000, by sector

Sector	Innovated products and services 1998-2000
Manufacturing of food, beverages & tobacco	49
Manufacturing of textiles, clothing & leather products	46
Manufacturing of wood & paper (products), publishing & printing	73
Manufacturing of chemicals, rubber and plastic products	56
Manufacturing of metal products, machinery, and equipment	65
Manufacturing of electrical and optical equipment	92
Manufacturing of transport equipment	75
Manufacturing of furniture, and n.e.c.	39
Wholesale	49
Transport and communication	39
Financial intermediation	45
Business services	50
Total	57

A majority of firms reported that they innovated products/ services (57%). Just like the number of firms that had technological innovation, this number varies considerably

between sectors. A relatively high percentage was found in the sectors: manufacturing of electrical and optical equipment (92% of the firms, innovated products), manufacturing of transport equipment (75%), and manufacturing wood, paper, and publishing (73%). A relatively low percentage in the sectors: transport and communication (61% of the firms did not innovate products), manufacturing of furniture & n.e.c. (61%), the manufacturing of textiles, clothing & leather products (54%), and financial intermediation (55%).

Table 4.5: Percentage of firms with innovated product and/or service 1998-2000, by size classes

Size class	Product and service innovations in 1998-2000?
< 50 employees	51
50 to 250 employees	72
250 to 500 employees	72
> 500 employees	75
Total	57

When firms are divided into size classes, as was done in table 4.5, a clear distinction can be made between the small firms (<50 employees), and the medium sized and large firms. Small firms are much less likely to innovate products and/or services (51%), then the larger firms (>72%).

Table 4.6: Third party involvement in product and service innovations

	Percentage
Products/services developed mainly by a third party	20
Products/services developed together with third party	12
Products/services developed mainly by own firm	33
No product and service innovations	43

Firms that indicated that product and/or services were innovated between 1998-2000 were asked whether there were third parties involved in the development of the improved or new product/service.
As can be seen in table 4.6, most firms innovate on their own (33%). A relatively large part of the development of new or improved products and/or services was done by a third party (20%), suggesting that a relatively large part of innovation in South Africa is purchased.

4.2.4 Innovated processes

Besides innovating products or services, organisations can also innovate their processes. To get an impression of the rate of process innovation among South African firms in manufacturing and services, firms were asked to report whether or not they brought improved or new production processes into use in the period 1998-2000. Improved processes were defined as existing production processes with clearly higher output performance, less costs or improved production reliability. New processes points to production processes that are incomparable with previous processes and in which new technology is embodied.

Process innovation and sector:

The bottom row of Table 4.7 shows that about 39% of the firms had process innovations in the period 1998-2000. Compared to the rate of product and service innovations (57%), this figure is clearly lower. Moreover, on average rates of process innovation are higher in manufacturing sectors compared to service sectors. That service sectors have lower rates of process innovation could be explained by the fact that in comparison to manufacturing sectors, service sectors have fewer processes to innovate. Table 4.7 also

shows to what extent there are sectoral differences with regard to the rate of process innovations.

Table 4.7: Percentages of firms with innovated processes 1998-2000, by sector

Sector	Innovated processes 1998-2000?
Manufacturing of food, beverages & tobacco	55
Manufacturing of textiles, clothing & leather products	27
Manufacturing of wood & paper (products), publishing & printing	53
Manufacturing of chemicals, rubber and plastic products	53
Manufacturing of metal products, machinery, and equipment	47
Manufacturing of electrical and optical equipment	67
Manufacturing of transport equipment	58
Manufacturing of furniture, and n.e.c.	37
Wholesale	15
Transport and communication	15
Financial intermediation	31
Business services	31
Total	39

As can be seen, there are clear differences between sectors. Relatively high rates of process innovations can be found in manufacturing of electrical and optical equipment (67% of the firms in this sector); manufacturing of transport equipment (58%), and manufacturing of food, beverages and tobacco (55%). Firms that are part of the wholesale sector (15%), and transport and communication (25%), and manufacturing of textiles, clothing & leather products (27%) report relatively low process innovation rates. Often the type of goods or services produced and the way these goods or services are fabricated cause these differences. Sectors characterised by large series or mass-production technologies, like for example food & beverages and automobiles, have a strong orientation towards this type of innovations to further optimise their processes.

Product/service and process innovators compared:

Comparing the distributions of Table 4.4 and Table 4.7 leads to some interesting results. These are summarised in Table 4.8 in which sectors with above and below average rates of product/service innovations on the one hand and process innovations on the other hand are classified. This table is compiled as follows: sectors were ranked from 1 to 12 according to the percentages of firms with product/service and process innovations, respectively. Next, both rankings were divided into three groups. The four sectors ranked highest were labelled ‘high’, the next four sectors received the label ‘medium’, and the four sectors with the lowest rankings were labelled ‘low’. The combination of the two ranking lists is shown in Table 4.8.

Table 4.8: Sectors with high, medium and low rates of product/service and process innovations

		Rate of product and service innovations		
		Low	Medium	High
Rate of process innovations	Low	Textiles, clothing, leather Transport & Communication	Wholesale	
	Medium	Furniture & n.e.c. Financial intermediation	Business services	Metal products, machinery & equipment
	High		Food, beverages & tobacco Chemicals, rubber & plastics	Wood, paper & publishing Electrical and optical equipment Transport equipment

Three sectors have high percentages of firms with product/service innovations as well as high percentages of firms with process innovations: manufacturing of wood, paper & publishing; manufacturing of electrical and optical equipment; and manufacturing of

transport equipment. In terms of the relative number of firms with innovative activities, the firms in these sectors can be labelled highly innovative.

Sectors with both low levels of product/service and process innovations can be found in the upper left cell of the table. It concerns manufacturing of textiles, clothing and leather, and the service sector transport and communication. These sectors have a relatively low innovative activity level.

Process innovations and size:

In table 4.9 firms with and without process innovation in the period 1998-2000 are categorised by size classes.

Table 4.9: Firms with process innovations 1998-2000, by size class

Size class	Process innovations in 1998-2000
< 50 employees	32
50 to 250 employees	55
250 to 500 employees	59
> 500 employees	65
Total	39

It can be seen that there is a clear size effect. The larger firms are, the higher the percentage of firms with innovated processes is. About 32% of firms with less than 50 employees bring this type of innovations into use, while for firms with 500 employees or more the same percentage has increased to 65%.

Partially, the seemingly relation between size and process innovation can be explained by the sector composition of the population. In general, service firms have a smaller size in comparison to firms in manufacturing. At the same time, we have learned (see the previous table) that firms in the service sector tend to have lower rates of process innovations. Therefore, Table 4.9 shows a relatively low number of firms with process innovations in the size class of firms with less than 50 employees.

Process innovations and third party involvement:

The fact that firms innovate their processes does not necessarily mean that they generated these innovations themselves. In order to find out to what extent third parties were involved in bringing technologically improved or new production processes into use, firms with process innovations were asked to indicate whether they developed process innovations on their own; together with a third party or whether the development was mainly in the hands of a third party. Table 4.10 shows the results. It should be noted that firms were allowed to answer more than one possibility. As a result the percentages in the table do not necessarily add up to 100%.

Table 4.10: Third party involvement for the development of process innovations

	Percentage
Processes developed mainly by a third party	9
Processes developed together with third party	9
Processes developed mainly by own firm	25
No process innovations	61

As was noted before, an estimated 61% of firms in the population did not have any process innovations in the period 1998-2000. Firms that brought technologically new or improved production processes into use primarily developed these innovations on their own. About 25% of the firms with process innovations walked this road. On the other side of the spectrum, process innovations can be developed outside the firm and thus mainly by a third party, often suppliers of machines and tools. It turns out that about 9% use this option. Another 9% of the firms developed process innovations together with a third party. The emerging picture from the figures presented in Table 4.10 is that South African process innovators are relatively autonomous when it comes to the development of this type of innovations, although a significant proportion use external parties to develop improved or new production processes.

4.2.5 Characteristics of innovations

One way of distinguishing innovations is to categorise them into types, i.e. product, service, or process innovations. Since an innovation is by definition something new, it is

also interesting to investigate the rate of newness of these innovations. With regard to this newness, the distinction between incremental and radical innovations is often used in literature. Incremental stands for innovations new to the market or the sector, whereas radical points to innovations new to the world. In both cases, newness is evaluated against all already existing services, products, and processes. Because this is a hard job to research, and also because the pure radical innovations are extremely rare, this survey uses a different typology. Innovating firms were asked to typify the rate of newness of their innovations. Because innovation was defined as a new or substantially improved service, product or process taking the firm as the point of departure, the indicator for the rate of newness used here takes the same position. Thus, firms were asked to evaluate the nature of innovations they had generated in terms of the amount of changes in their own products, services or processes. To answer this question, firms were presented two possibilities: step-by-step changes and drastic changes of products, services or processes.

Table 4.11: Nature of innovations

Nature of innovations	Type of innovations	
	Product/service innovation	Process innovation
Step-by-step changes	85	87
Drastic changes	15	13

As can be concluded from Table 4.11, a vast majority of innovating firms innovated in a step-by-step way. This is true for firms with product/service innovations (85% step-by-step) as well as for firms with process innovations (87%). A second conclusion is that only a relatively small number of firms characterise their innovations as drastic. For both type of innovations about 15% of the innovating firms state that this is the case.

4.3 Objectives of innovation

Through innovation, firms try to aim at specific goals. To find out which objectives were important for innovating South African firms, they were asked what was the importance of the objectives mentioned below for their technological innovation projects between 1998-2000. The following objectives were distinguished in the SAIS 2001-questionnaire:

- Products or market objectives, which comprises improving product or service quality, extending product or service range, and opening up new markets;
- Labour related objectives: Reducing deployment/costs of labour;
- Flexibility objectives: Improving internal business process flexibility;
- Materials: Reducing material consumptions in production;
- Environmental objectives: Reducing environmental damage.
- Regulations: Fulfilling regulations and standards.

The firm's responses are summarized in Table 4.12. The majority of South African firms saw as their most important objective of innovation, improving product or service quality, extending product or service range, and opening up new markets.

Table 4.12: Objectives of innovation

Importance of objectives	Percentage of firms indicating level of importance for objectives of innovation.					
	Products/ market	Labour	Flexibility	Materials	Environ-ment	Regulation
Not important	5	33	28	32	46	36
Fairly important	4	22	19	17	22	18
Important	26	27	30	25	16	22
Very important	65	18	23	26	16	24

Reducing costs of labour, improving internal business flexibility, reducing material consumption in production and fulfilling regulations and standards form a second group objectives of innovation. About 50% of innovating South African firms regard these goals as important or very important. Interestingly, only 16% states that reducing environmental is an important innovation goal, while another 16% regards this objective as very important to their firm. Although environmental issues are high on the policy agendas of many governments, innovating firms in South Africa seems to have other innovation objectives.

4.4 Factors Hampering Innovation

In this section, the focus is on factors hampering innovation. Numerous problems can occur ranging from lack or resources in terms of money, knowledge or qualified personnel to different kinds of uncertainties that have their effects on the progress and results of processes of innovation.
To describe to what extent South African firms are confronted with innovation problems different issues are discussed in this section. First, in subsection 4.4.1, it is described to what extent firms abandoned innovation projects in the period 1998-2000. Next, the question is raised why firms did not innovate at all in the period of this study (4.4.2). Subsection 4.4.3 describes effects of bottlenecks on the progress of innovation projects. Finally, in subsection 4.4.4, the analyses of subsection 4.4.3 are taken a step further: the nature of the problems innovating firms encounter and their effects are analysed more in depth.

4.4.1 Firms with abandoned innovative projects

A clear indication of problematic innovation processes is the number of firms that abandon innovation projects before completion. Problems encountered during the innovation process can be so severe, that innovators decide to stop all research, development and engineering activities. Table 4.13 provides some details about the frequency of this phenomenon in the period 1998-2000.

Table 4.13: Abandoning innovation projects before completion 1998-2000, by size class

Size class	Innovation projects abandoned before completion, 1998-2000
< 50 employees	13
50 to 250 employees	16
250 to 500 employees	19
> 500 employees	26
Total	14

About 14% of innovating South African firms state that innovation projects are for some reason terminated before completion. Although there is no clear size effect, i.e. the differences between the size classes are not statistically significant; there is some indication that especially large firms (with 500 employees or more) take this decision more often in comparison to firms of smaller sizes. Whether this is the result of more complicated or more problematic projects is a question that cannot be answered here: about 26% of the firms in this size class abandoned innovation projects before completion in the period under study. In other size classes the percentage of firms that

abandon projects in clearly lower, ranging from 19% of the innovating firms is the size class 250 to 500 employees to 13% in the size class encompassing the smallest firms.

4.4.2 No technological innovative activities

Table 4.14: Reasons for no technological innovative activities explained

Reason	Explanation
Economic risks	Cost-benefit analyses had too many uncertainties
Costs too high	Estimated innovation costs too high for our firm
Short of staff	Lack of qualified personnel
No time	No time within the firm for innovative activities
Time to market	Could not meet required market introduction
Short of finance	Lack of appropriate external financial resources
Demand risks	Too many uncertainties (future) product markets
Third party already innovated	A third party (parent, licensor) already generated innovations
Market reasons	Our market is too small or signals no new needs
Other reasons	

In section 4.2, it was concluded that about 56% of the population of South African firm in manufacturing and services did not innovate in the period between 1998 and 2000. For scientific as well as policy purposes, it is of importance to find out why firms decided not to innovate. After all, specific reasons put forward by non-innovating firms could motivate policy makers to intervene with measures counteracting certain bottlenecks. In the survey, a separate question on this issue was included. Before the results on this question are presented and discussed, a brief clarification of the items used in the questionnaire is presented. This enables the reader to get a better understanding of the reasons that firms mention.

A number of reasons mentioned above refer to a lack of resources (costs too high, short of finance, short of time), while other reasons are related to uncertainties that are associated with the act of innovating (uncertain outcomes of cost-benefit analyses, market uncertainties).

Table 4.15: Main reasons for no technological activities 1998-2000

Reason	No technological activities between 1998-2000 because:
Economic risks	41
Costs too high	52
Short of staff	38
No time	46
Time to market	15
Short of finance	45
Demand risks	40

About 52% of firms that did not innovate in the period 1998-2000 indicated that they behaved in this way because the estimated costs of (planned) innovation projects were too high. Another 45% stated that they did not innovate because they experienced a lack of appropriate external financial resources. The third main reason for no technological innovation is lack of time. About 46% of the firms with no technological innovative activities give this reason. Economic risks, short of staff, and demand risks are almost equally important reasons to show no innovative activity: in each case about 40% of the firms named one of these reasons. A small number of firms, about 2% of the firms without innovations, named other reasons for their non-innovative behaviour than the ones already indicated in the questionnaire. Some of these 'other reasons not to innovate' are: there is a third party (often a parent company or a licensor) already

responsible for innovative activities; there is no market need for innovations or the market is too small; or there is just a lack of new ideas.
The three main reasons not to innovate are clearly related. All three point to a lack of resources in terms of money, staff and time for innovation projects. A second related, but slightly less important group of reasons refers to uncertainties and risks that are typical for innovation processes: uncertainties about outcomes in terms of revenues (cost benefit) and (future) market developments (market risks).

Table 4.16: No technological activities 1998-2000, main reasons per sector

Sector	Main reasons
Manufacturing of food, beverages & tobacco	Short of finance; costs too high; short of staff
Manufacturing of textiles, clothing & leather products	Costs too high; economic risks; demand risks
Manufacturing of wood & paper (products) and publishing	Short of staff; demand risks; costs too high
Manufacturing of chemicals, rubber and plastic products	Costs too high; short of finance; demand risks
Manufacturing of metal products, machinery & equipment	Costs too high; short of finance; short of staff
Manufacturing of electrical and optical equipment	Short of staff; demand risks; economic risks
Manufacturing of transport equipment	Short of staff; short of finance; economic risks
Manufacturing of furniture, and n.e.c.	No time; short of finance
Wholesale	No time
Transport and communication	Short of staff; costs too high, economic risks
Financial intermediation	Economic risks; costs too high; demand risks
Business services	Costs too high; short of finance

Table 4.16 answers the question whether specific reasons not to innovate are typical for a sector. The table lists the reasons most often mentioned by firms in a sector.

With a few exceptions, there are no clear differences between the overall and the sectoral picture. The main reasons why firms did not innovate stay more or less the same for most of the sectors: shortages of appropriate external financial funds and the costs of innovation are regarded as too high for the firm. For some sectors, one or both of these reasons are complemented with other reasons. One way to categorize these sectors is to look at the importance of resource deficits versus the risks of innovation as reasons for no technological activity. In some sectors, like manufacturing of food, beverages & tobacco, manufacturing of wood, paper and printing, manufacture of metal products, or manufacture of chemicals and plastics, lack of resources is the dominant reason for non-innovative behaviour. For other sectors, the risks and uncertainties of innovating come up as important. This is true for manufacturing of textiles, clothing & leather products, manufacturing of electrical and optical equipment and financial intermediation.

Another question one could raise is whether small firms give other reasons for a lack of technological activity than large firms. Table 4.17 gives an indication whether or not this is the case.

Table 4.17: No technological activities 1998-2000: two most important reasons per size class

Size class	Two most important reasons
< 50 employees	Costs too high; no time
50 to 250 employees	Costs too high; short of staff
250 to 500 employees	Costs too high, no time
> 500 employees	Costs too high, demand risks

It is clear that there are no clear differences between the size classes. Firms in all size classes state that the estimated costs of innovation are so high that they decide not to innovate at all. With the exception of the firms with 500 employees or more, firms indicate that lack of resources inhibits innovation.

4.4.3 Innovation and bottlenecks

In this section, the focus is on South African firms with innovations and the effects of the bottlenecks they experience on the progress of innovation projects. In case innovating firms had bottlenecks, three kinds of effects were distinguished: innovation projects were planned but did not start, projects were stopped prematurely, or projects were seriously delayed because of the bottlenecks encountered. It should be noted that firms were allowed to answer where appropriate. In other words, one innovating firm could have experienced all types of effects.

It is clear from Table 4.18 that bottlenecks especially cause serious delays of innovation projects. About 40% of firms with innovations indicate that this is the case. Another 28% experienced bottlenecks that resulted in the decision not to start a planned innovation project. About one of every five innovating firms indicates that because of certain bottlenecks, projects were stopped prematurely.

Table 4.18: Innovation and bottlenecks, effects on innovation projects

Effects of bottlenecks on innovation projects	Experienced bottlenecks resulted in:
Innovation projects were planned but not started	28
Innovation projects were stopped prematurely	20
Innovation projects were seriously delayed	40

Firms that indicated that they experienced at least one of the effects of bottlenecks mentioned above were asked to specify the type of bottleneck and to indicate the effects of this specific bottleneck on the progress of their innovation projects. In the next section, these topics are discussed.

4.4.4 Factors hampering innovation: effects on innovation projects

The survey distinguished ten specific bottlenecks that are described with a brief explanation in Table 4.19.

Table 4.19: Factors hampering innovation, a brief explanation

Type of bottleneck	Explanation
Economic risks	Cost-benefit analyses presented too many doubts
Short of staff	Lack of qualified personnel
Knowledge gap	Lack of information/familiarity with technologies
Costs too high	Estimated costs too high/exceeding initial budget
Short of finance	Lack of appropriate external financial sources
Time to market	Could not meet required market introduction time
Partnership	Cooperation with partners not proceeding smoothly
Demand risks	Too many uncertainties on (future) product markets
Regulations	Restrictive public or other government regulations
Rigidities	Internal organisational rigidities hampered innovation

Bottlenecks like short of staff, knowledge gap, short of finance point to a lack of internal resources hampering innovation, whereas economic and demand risks indicate high perceived uncertainties associated with innovating.

First, the most important bottlenecks hampering innovation are identified. Next, the effects of specific bottlenecks will be described.

If one takes the inverse of the column 'no bottleneck', one can determine which bottlenecks are hampering projects of innovating firms. It turns out that a lack of qualified staff is the bottleneck most often put forward by innovating firms. About 70% of innovating firms are experiencing this bottleneck. Second and third in row are economic risks and demand risks: 63% of the innovators indicate that cost-benefit analyses of their innovation projects presented too many doubts, while 59% are confronted with too many uncertainties about (future) product markets. Shortages of finance are also an important bottleneck: 59% of the innovators experience a lack of appropriate external financial resources that hamper their innovation process.

Table 4.20: Factors hampering innovation and their consequences

Bottlenecks	No bottleneck	A bottleneck and as a result innovation projects were		
		Not started	Abandoned	Seriously delayed
Economic risks	37	22	4	36
Short of staff	30	14	3	53
Knowledge gap	47	11	3	39
Costs too high	43	11	11	34
Short of finance	41	15	11	33
Time to market	50	6	7	36
Partnership	70	6	7	17
Demand risks	41	19	10	30
Regulations	62	12	7	20
Rigidities	66	4	4	26
Other bottlenecks	21	54	6	19

The combination of bottlenecks experienced by firms and their effects on innovation projects leads to some interesting observations:

- Innovation projects were not started in particular because of economic risks and demand risks. In other words, planned projects are not started because of uncertainties and risks associated with possible outcomes of innovation projects;
- Important reasons for abandoning projects before completion are financial problems. Because initial budgets are exceeded, costs of projects are too high, or additional funds are lacking, innovation projects are terminated before the actual innovation is generated;
- Serious delays of innovation projects are caused by two related bottlenecks: lack of qualified personnel and lack of information/familiarity with technologies. In both cases, delays are caused by internal knowledge deficits.

4.5 Management of innovation

Technology management plays a very important role in achieving the goals of a firm. Technology management practices include proper planning, organising and control processes. In this section, the focus is on the technology management practices of the firms who indicated that they had innovative activities. Firms were asked about their technology strategies, training of personnel in the theory and practice of technology and innovation management, and the responsibility and decision making levels of the technology managers. Of interest is also which technology and innovation management tools firms are employing to support the management of innovation.

4.5.1. Technology strategy

The existence of a technology strategy in a firm is an indication of the firm's standing towards technology and innovation. Firms were asked to indicate if the firm has a technology strategy or not. From the total number of South African firms that do have technological innovations for the period 1998 - 2000, 32% indicated that they have a technology strategy. Table 4.21 gives an indication of the distribution across the different size classes. There seems to be a positive correlation between firm size and the firm having a technology strategy.

Table 4.21: Percentages of firms having a technology strategy, by size class

Size classes	Availability of a technology strategy
< 50 employees	25
50 to 250 employees	39
250 to 500 employees	58
> 500 employees	59
Total	32

Table 4.22 shows a breakdown of firms having technology strategies, divided into sectors. No firm in the wood, paper and publishing sector indicated that it had a technology strategy. On the other hand, 96% of firms in the financial sector indicated that they do have technology strategies. For the rest of the sectors the percentage varies from 15% – 50% for firms indicating that they do have a technology strategy.

Table 4.22: Percentages of firms with a technology strategy, by sector

Sectors	Technological strategy
Manufacturing of food, beverages & tobacco	36
Manufacturing of textiles, clothing & leather products	45
Manufacturing of wood & paper (products), publishing and printing	0
Manufacturing of chemicals, rubber & plastic products	31
Manufacturing of metal products, machinery, & equipment	29
Manufacturing of electrical & optical equipment	50
Manufacturing of transport equipment	42
Manufacturing of furniture, & n.e.c.	20
Wholesale	15
Transport and communication	20
Financial intermediation	96
Business services	37
Total	32

4.5.2 Training in technology and innovation management

Training employees in the functional areas they are responsible for is very important, as it will improve their efficiency and effectiveness. The same can be argued for employees who are responsible for the innovation activities in the firm. Innovating firms were thus asked if any of their employees attended training courses in technology and/or innovation management during the period 1998 - 2000. Employees of 40% of South African firms attended such training courses. Table 4.23 gives the distribution across the different size classes. It is clear that the larger firms have a much higher tendency to provide their employees with the necessary training in the field of technology and innovation.

Table 4.23: Firms providing training in technology and/or innovation management, by size class

Size classes	% of firms providing training
< 50 employees	37
50 to 250 employees	41
250 to 500 employees	58
> 500 employees	69
Total	40

Table 4.24 shows a breakdown of the percentage of firms divided into sectors that are providing training in technology and/or innovation management to their employees. The wood & paper (products) & publishing and printing sector had the lowest training profile with only 21% of firms in this sector providing such training. The business services sector has the highest profile with 60% of the firms indicating that they provide such training to their employees.

Table 4.24: Firms providing training in technology and/or innovation management, by sector

Sector	Providing training
Manufacturing of food, beverages & tobacco	23
Manufacturing of textiles, clothing & leather products	45
Manufacturing of wood & paper (products), publishing and printing	21
Manufacturing of chemicals, rubber & plastic products	40
Manufacturing of metal products, machinery, & equipment	38
Manufacturing of electrical & optical equipment	58
Manufacturing of transport equipment	33
Manufacturing of furniture, & manufacture n.e.c.	34
Wholesale	26
Transport and communication	57
Financial intermediation	42
Business services	60
Total	40

4.5.3 Person for technology management

Firms were also asked if there is a person within their organisational structure responsible for the management of technology. About 65% of South African innovating firms indicated that they do have such a person. Although not specifically asked to respondents, it can be assumed that some firms would classify their Information Technology managers in this category. The firms were also asked on which level of management the responsible person is operating. In 89% of the firms the responsible person is a member of senior management, 8% of middle management and 3% of junior management. Table 4.25 shows the distribution across the different size classes. The 250 to 500 employees size class has the highest percentage of firms (78%) with a person responsible for technology management.

Table 4.25: Person responsible for technology management, by size class

Size class	Percentage of firms
< 50 employees	58
50 to 250 employees	69
250 to 500 employees	78
> 500 employees	68
Total	62

4.5.4 Technology and innovation management tools

It is important that firms utilise proper tools to support their technology and innovation efforts, especially from a management support point of view. Through the questionnaire, firms were provided with a list of possible technology and innovation management tools and asked to indicate which tools they used during the period 1998 to 2000. The results are shown in Table 4.26. Market analysis tools are utilised by most of the firms (79%). In general it is clear that firms are highly concerned about competition in their respective markets, as can be seen from the three tools being utilised the most, namely market analysis (79%), industry analysis (72%) and competitor analysis (66%).

Table 4.26: Firms using technology and innovation management tools in the period 1998-2000

Type of technology and innovation tool	Use of technology and innovation tools
Technology monitoring and scanning	46
Technology forecasting and fore sighting	28
Competitive technological intelligence	41
Competitor analysis	66
Industry analysis	72
Market analysis	79
Technology / innovation audits of own organisation	32
Core competence of own organisation	53
Intellectual property audit of own organisation	29
Project portfolio management	28
Cross functional teams in innovation projects	30

4.6 Summary and conclusions

In this chapter, different throughput aspects of innovation processes of South African firms in manufacturing and services in the period 1998-2000 were analysed. The most important findings presented in this chapter are summarised below.

Technological innovative activity

About 44% of South African firms had technological innovations in the period 1998-2000. When distinguished into the type of innovation, it was found that about 57% of the firms produced product and/or service innovations, whereas about 39% innovated their production processes.

Sectoral innovation rates differed considerably. High technological innovation rates were observed in the electrical & optical equipment industry, the manufacturing of transport equipment, and the chemicals and plastic industry, while low levels were noted for wholesale, the textiles, clothing & leather industry, and financial intermediation. As far as product and/or service innovations are concerned, the electrical & optical equipment

industry, transport equipment industry, and the manufacturing of wood (products), paper (products), publishing & printing realised high product/service innovation rates. High process innovation rates were found in the transport equipment industry, the electrical & optical equipment industry, and in the food, beverages & tobacco industry.
A vast majority of innovations are incremental. Products, services, and processes are changed in a step-by-step way.
It is often assumed that large firms have higher innovation rates because they have more resources and profit more from economies of scale in innovation processes and projects. This assumption was confirmed in this research. Larger firms have higher product/service and process innovation rates.

In conclusion, South African firms in manufacturing show considerable technological innovative activity, although innovation rates are in general somewhat lower in comparison to European innovation rates. With the South African context, three sectors show relatively high product/service and process innovation rates: the manufacture of wood (products), paper (products), printing & publishing, manufacturing of electrical & optical equipment, and manufacturing of transport equipment. In case innovation rates are used as indicators of technological activities, these sectors are the national innovation champions. Relative low levels of product/service and process innovation rates are observed in two sectors: manufacturing of textiles, clothing & leather, and transport & communication.

Third party involvement for technological innovation

A relatively large part of the development of new or improved products and/or services was done by or together with a third party (32%). For process innovations, this percentage is much lower (18%). Therefore, one can conclude that South African process innovators are relatively autonomous when it comes to the development of this last type of innovations, whereas product innovations depend to a much higher extent on external knowledge and contributions. This last finding is in line with the observations in chapter 6.

Innovation in a broader sense

Besides technological innovations, firms can be innovative by changing for example their business strategies or by changing their organisation. In the period 1998-2000, changing business strategies and marketing were most often mentioned as other forms of innovative behaviour.

Objectives of innovation

Improving product and service quality, extending the product/service range and opening up of new markets were by far the most important objectives of innovation of South African firms in manufacturing and services. Other objectives, such as reducing labour costs or fulfilling regulations were less important. Reducing environmental damage was the least important innovation goal.

Main reasons for the absence of technological activities between 1998 and 2000

For scientific as well as policy purposes, it is of importance to find out why South African firms in manufacturing and services did not innovate. In order of importance, the main reasons for no technological activity were:

- The estimated costs of planned innovation projects were too high;
- A lack of appropriate external financial resources;
- A lack of staff and time.

These three main reasons not to innovate are clearly related and point to a lack of resources in terms of money, staff and time for innovation projects. A second related, but slightly less important group of reasons refers to uncertainties and risks that are typical for innovation processes: uncertainties about outcomes and (future) market

developments. There were no sectoral and size differences found with regard to the importance of the reasons not to innovate.

From a policy perspective, one might conclude that higher innovation rates could be accomplished in South Africa if more (governmental) funds would be made available.

Innovation and bottlenecks

A considerable percentage of South African firms that do innovate is confronted with bottlenecks that hamper their innovative activities. About 40% of South African firms experienced seriously delayed innovation projects. A lack of qualified personnel was most frequently experienced, followed by demand risks (uncertainties on (future) product markets) and economic risks (cost-benefit analyses of the projects presented too many doubts). Innovation projects were not started in particular because of economic risks and demand risks. In other words, planned projects are not started because of uncertainties and risks associated with possible outcomes of innovation projects; Important reasons for abandoning projects before completion are financial problems. Because initial budgets are exceeded, costs of projects are too high, or additional funds are lacking, innovation projects are terminated before the actual innovation is generated. Serious delays of innovation projects are caused by two related bottlenecks: lack of qualified personnel and lack of information/familiarity with technologies. In both cases, delays are caused by internal knowledge deficits.

In conclusion, South African innovating firms are facing a number of bottlenecks that seriously inhibit their innovation processes. The lack of qualified personnel as well as the lack of information about and familiarity with technologies both asks for tailored training programmes, since both bottlenecks point to knowledge deficits of innovators.

Technology strategy

About 32% of firms have a formal technology strategy. There is a clear indication that the larger the firm, the higher is the chance that it has a formal technology strategy in place. Since larger firms probably do employ more technologies in their broader operations than smaller firms, the need for a formal strategy to manage their technologies are higher. An interesting observation from the wood, paper and publishing sector is that they do not employ technology strategies at all. The only explanation for this behaviour is that very few radical technology changes take place in this sector, and the perception is therefore that formal strategies to manage the technology, is not necessary.

Training in technology and innovation management

About 40% of firms provide training in technology and innovation management to their employees. Larger firms tend to do this more often than smaller firms. Like with the occurrence of a technology strategy, this trend can probably also be related to the fact that larger firms employ more technologies. The result is that a higher number of technologies require a more intensive management effort, for which more training is needed. The wood, paper and publishing sector provides the least training in technology and innovation management, possibly for the same reason as was explained for their technology strategy effort.

Technology and innovation management tools

For the purpose of analysing the survey results, the technology and innovation management tools can be classified in three categories, namely tools to analyse the external technology environment, tools to analyse the internal technology capability and tools to analyse the business environment. Tools to analyse the business environment seems to be the most employed by firms (about 72% of firms). These include market, competitor and industry analysis. The use of tools to analyse the external technology environment and internal technological capability is much less, about 38% and 34% of firms respectively.

5. INTERNAL SOURCES FOR INNOVATION

5.1 Introduction

To be able to innovate, firms require resources (technical knowledge and techniques) and information (e.g. market, technological and competitor intelligence). The sources of such technology and information can be internal and/or external to the organisation.

In this chapter, the use of internal sources for innovation by South African firms in manufacturing and business services will be analysed. Theoretical as well as empirical research points at the importance of sufficient internal resources for innovation (Wernerfelt, 1984, Barney, 1991; Teece and Pisano, 1998; Combs and Ketchen Jr., 1999). In the context of innovation, internal resources are needed to come to the development of knowledge, competences, and capabilities.

Firms can use external resources for innovation when they lack internal resources (Oerlemans et al., 2001). This is however dependent on the firms internal ability to assimilate and use the externally acquired knowledge. To be able to innovate with external resources, firms need a critical amount of "absorptive capacity" (Cohen and Levinthal, 1989, 1990). This is of particular importance to South Africa that has been described as a "technology colony" (De Wet, 2001). Technology colonies are countries whose industries are dependent on foreign technology for production and innovation. Without sufficient internal R&D personnel, firms cannot transfer and implement technology properly and efficiently from external sources.

Therefore, internal sources perform two functions for innovation: they generate knowledge and information on the one hand, and they enable organization to absorb external knowledge on the other. In this chapter, the following internal resources are discussed: own research and development (R&D), human resources, innovation expenditures, and the use of and importance of internal information sources for technological innovation.

5.2 Own Research and Development

This section of the report examines firm's own Research & Development (R&D) inputs into the innovation process. Firms were asked to report on all in-house activities aimed at the development of technologically new or improved products, services or processes, including corresponding research and software development that can be labelled as R&D.

R&D effort 2000

The average number of persons engaged in R&D in 2000 was 3.54 per firm (or an average of 1.80% of the workforce of firms). Many of these persons were only part-time R&D workers, as the man-years spent on R&D in 2000 were only 2.2 man-years per firm. As expected, these figures increase with increasing firm size as shown in Table 5.1.

Table 5.1: R&D effort in 2000, by size class

Size Classes	R&D effort		
	Persons per firm	Man-years per firm	Innovation costs per firm
< 50 employees	1.23	0.53	R0.917 million
50 to 250 employees	3.92	2.35	R2.706 million
250 to 500 employees	11.01	10.93	R4.767 million
> 500 employees	39.93	22.38	R33.651 million

R&D expenditure data provided by firms is a primary indicator of innovation activity. However, it has long been recognised that R&D personnel data is not sufficient for the analysis of innovative behaviour of firms and the non-R&D costs of innovation must also be considered (see Section 5.4). Firms were therefore asked to include personnel costs and related investment expenditures (no depreciation). An important advantage of this survey is that it was not limited to R&D input figures only, but also includes other innovation costs and expenditures. As a result, a more comprehensive picture of innovation input efforts is presented.

It was found that the mean innovation costs in 2000 were R2.57 million per firm. Again, as with the number of persons engaged in R&D, innovation costs increases with firm size as shown in Table 5.1.

R&D intensity 2000 in persons

The figures presented in Table 5.1 give an indication of the absolute number of persons allocated to R&D resources and the absolute amount of innovation costs per firm. However, absolute values do not give a true picture of the intensity with which South African firms invest in research and development resources. After all, a firm with 50 employees that has 5 full-time R&D workers (R&D intensity = 10%) should be regarded as more R&D intensive than a firm with 1000 employees and 40 R&D workers (R&D intensity = 4%). Therefore, the R&D intensity of South African firms in manufacturing and services has to be estimated. In the survey, the R&D effort was measured as the percentage of workers in the total workforce of an organization performing research and development activities. In Table 5.2, the distribution of firms in classes of R&D intensity is presented.

Table 5.2: R&D intensity classes 2000

R&D intensity class	Percentage of firms	Cumulative percentage
0%	51.2	51.2
0.01 to 1.50%	14.9	66.1
1.50 to 3.00%	16.9	83.0
3.00 to 4.50%	8.9	91.9
4.50 to 6.00%	1.4	93.3
6.00% or more	6.7	100.0

About 51% of all South African firms in manufacturing and services had an R&D intensity of 0%, thus no R&D activities in 2000 in terms of persons working on research and development activities. The companies with R&D can be divided in two groups. The first group (about 32% of all firms) has a fairly low R&D intensity level. Between 0.01 and 3.00% of the total workforce in these firms conducts R&D activities. The second group (about 7% of all firms) can be labelled R&D intensive: 6% or more of all employees are

devoted to R&D activities. The average R&D intensity 2000 in persons of all firms is 1.8%.

There are significant differences between the R&D intensities of firms in different sectors, as can be concluded from Table 5.3.

Table 5.3: R&D intensity 2000 (% of workforce), by sector

Sector	R&D intensity 2000 (% of workforce)
Manufacturing of food, beverages & tobacco	0.59
Manufacturing of textiles, clothing & leather products	1.27
Manufacturing of wood & paper (products), publishing and printing	1.50
Manufacturing of chemicals, rubber & plastic products	2.21
Manufacturing of metal products, machinery & equipment	1.83
Manufacturing of electrical & optical equipment	7.73
Manufacturing of transport equipment	1.72
Manufacturing of furniture & other manufacturing	3.31
Wholesale	0.56
Transport and communication	0.87
Financial intermediation	0.36
Business services	3.67
Total	1.80

Four sectors display relatively low R&D levels: manufacture of food, beverages & tobacco, wholesale, transport & communication, and financial intermediation, with R&D intensity levels below 1% of the total workforce. The manufacture of electrical & optical equipment, the chemical industry, the manufacture of furniture & other manufacturing, and the business services sector turn out to be relatively R&D intensive. They all had R&D intensity levels above 2%.

Table 5.4: R&D intensity 2000 (% of workforce), by size class

Size class	R&D intensity
< 50 employees	4.58
50 to 250 employees	2.92
250 to 500 employees	3.20
> 500 employees	0.94
Total	1.80

The R&D intensity of firms divided into size classes is shown in Table 5.4. Two conclusions can be derived from the findings. First, R&D intensity turns out to be size dependent. Although it often reported that larger firms are more R&D intensive in comparison to smaller firms, the opposite pattern is found in this research. Second, especially small firms tend to be very R&D intensive. On average about 4.5% of their workforce is involved in R&D activities. Kleinknecht & Reijnen (1991) reported a similar finding for the Netherlands. That is to say, the proportion of small firms with innovation is smaller as compared to large firms, but small firms that do innovate tend to be more R&D intensive.

R&D related innovation costs 2000

Another way to express the amount of resources that firms spend on research and development activities is to look at the monetary investments made in R&D. Firms were asked to provide their R&D related innovation costs, including personnel costs and related investment expenditures for the year 2000. To correct for size effects, the R&D related innovation costs were divided by total firm sales 2000. As a result, R&D related innovation costs 2000 are expressed as a percentage of sales 2000. Table 5.5 shows these percentages for every sector.

Table 5.5: R&D related innovation costs 2000 (% of sales 2000), by sector

Sector	R&D related innovation costs 2000 (% of sales 2000)
Manufacturing of food, beverages & tobacco	1.74
Manufacturing of textiles, clothing & leather products	0.25
Manufacturing of wood & paper (products), publishing and printing	0.58
Manufacturing of chemicals, rubber & plastic products	5.77
Manufacturing of metal products, machinery & equipment	0.80
Manufacturing of electrical & optical equipment	1.57
Manufacturing of transport equipment	9.37
Manufacturing of furniture & other manufacturing	1.33
Wholesale	0.43
Transport and communication	3.88
Financial intermediation	0.15
Business services	2.60
Total	1.55

In 2000, South African firms in manufacturing and services invested 1.55% of their sales in R&D projects. Again, significant differences between sectors can be observed. Relatively high figures can be noted for the transport equipment industry, the manufacturing of chemicals, rubber & plastic products, and the transport and communication sector. Relative low levels were found for financial intermediation, the manufacturing of textiles, clothing & leather products, wholesale, and the metal products, machinery & equipment industry.

Table 5.6 shows the R&D related innovation costs 2000 as a percentage of total sales 2000 for each size class.

Table 5.6: R&D related innovation costs 2000 (% of sales 2000), by size class

Size class	R&D related innovation costs 2000 (% of sales 2000)
< 50 employees	5.90
50 to 250 employees	0.72
250 to 500 employees	2.42
> 500 employees	1.91
Total	1.55

Firstly, there is no positive correlation between size class and percentage of sales spend on R&D related activities. In other words, investments in R&D projects do not vary with size. Secondly, it turns out that firms with less than 50 employees invest almost 6% of their sales in R&D projects. This is an interesting finding because it again shows that a number of small South African firms are R&D intensive.

5.3 R&D Expenditure in South Africa

One of the most important internal sources for innovation activities of firms is R&D. Other surveys (DACST, 2000, NACI, 2002) found that South Africa's total estimated Gross Expenditure on R&D (GERD) was R4.1 billion per annum for 1997/98 and was R5.725 billion per annum for 2000. These figures exclude military R&D, research done by research Non-Governmental Organisations (NGOs) and research consultancies (NACI, 2002). GERD as a proportion of Gross Domestic Product (GDP) (at current market prices) shows a small increase (from 0.60% in 1997/98 to 0.64% in 2000). However, these figures have to be adjusted for underestimated higher education expenditure (where differing survey methods were used) (NACI, 2002). When this is done the picture is markedly different, showing a sharp decline (of 8%) in the proportion of GERD to GDP between 1997/98 and 2000 (NACI, 2002).

The Department of Arts, Culture, Science and Technology's 1997/98 R&D survey (DACST, 2000) gives the R&D expenditure in the business sector as R2.2 billion in 1997. The R&D expenditure for 2000 was estimated by DACST at R2.5 billion, based on the 1997 figure plus an annual increase of 5%. This could be an overestimation, as a survey of the 17 largest corporations in the country undertaken early in 2002 by DACST found that R&D expenditure had declined from 1.46% to 0.97% of the total company budgets between 1997 and 2001. Of the estimated R2.5 billion spent in 2000 on R&D by the business sector, R500 million was contracted to Science Councils and other National Facilities while R2 billion was spent on internal R&D done by industry (NACI, 2002).

For the sake of comparison and validation of population estimates, GERD as a proportion of GPD was calculated using the SAIS 2001 survey data on R&D expenditures 2000 on the one hand and GDP estimates for the year 2000 (in current prices) as published by the OECD (August 2003) on the other hand. The resulting figure for 2000 turned out to be 0.57%, which comes very close to the estimate presented in the above.

5.4 Other innovation expenditures in 2000

In most countries, there is a long tradition in collecting data on R&D, but there is a lack of data on other main categories of innovation expenditure. This is a serious omission, since one of the most important themes of modern innovation analysis has been the importance of non-R&D inputs to innovation (Evangelista et al., 1997). A related issue is expenditure on the acquisition of capital and intermediate goods, embodying new technologies. This type of investment, which is linked to both product and process change, has long been recognised as a key carrier of technological advance.

In order to capture these types of non-R&D expenditures, firms were asked to indicate whether they applied any of the following innovation-related activities in 2000 and to give estimates of related expenditures:

- *Purchase of machinery and equipment*: Purchase of advanced equipment or computer hardware specifically purchased for innovative purposes.
- *Outsourcing research*: All creative, systematic research performed to develop technological innovations, including corresponding research and software development performed by third parties by order of your firm. This includes costs of specialists that were temporarily employed by a firm to work on an innovation.
- *Industrial Design and/or Innovation Implementation:* All activities aimed at the technical preparation of production processes in order to bring an innovation into production (and not already taken into account in the previous two items).
- *Licenses/Advices:* Acquisition of patents, purchase of non-patented inventions and/or other expertise not mentioned before, for example in the field of software or information technology.
- *Marketing:* Costs of marketing activities (also done by others) as far as directly related to the market introduction of innovated products/services (including market research).
- *Training:* Costs of training of personnel (also done by others) as far as directly related to the market introduction of innovated products, services, or processes.

Approximately a third of the firms in South Africa applied these innovation activities in 2000 as shown in Table 5.7. The highest cost was for the purchase of machinery, equipment or computer hardware specifically purchased for innovative purposes, this accounted for almost half of the total costs of innovation. These findings support the view that the purchase of machinery and equipment is an important external source of

embodied technology. About one third of all South African firms invested in marketing and training directly related to the market introduction of innovated products and services.

Table 5.7: Type of innovation expenditures in 2000

Innovation expenditure	Percentage of firms that had this type of costs	Average innovation costs per firm
Machinery/ Equipment	34.0%	R0.68 million
Outsourced Research	20.3%	R0.13 million
Industrial Design and/or Innovation Implementation	21.6%	R0.24 million
Licenses/Advices	10.2%	R0.11 million
Marketing	28.4%	R0.24 million
Training	29.3%	R0.22 million

Besides expenditures on machinery and equipment, about 30% of South African firms had innovation related expenditures on marketing and training. On average, firms invested about R 0.2 million on each of these activities. Approximately 10% of South African firms had costs related to the acquisition of patents or the purchase of non-patented inventions and expertise. The average innovation costs per firm for licenses and advised were R 0.1 million.

5.5 Total innovation expenditures 2000

In this section, the total innovation expenditures 2000 of South African firms in manufacturing and services are presented. Total innovation expenditures include R&D and non-R&D investments as discussed in previous sections of this chapter. First, the total innovation expenditures 2000 expressed in Rand will be discussed. Second, total innovation expenditures will be expressed as a percentage of total sales 2000. This normalisation corrects total innovation expenditures 2000 for size effects. In other words, total innovation expenditures are presented per monetary unit of sales.

Table 5.8: Total average innovation expenditures 2000 per firm, in million ZAR, by sector

Sector	Total innovation expenditures 2000
Manufacturing of food, beverages & tobacco	R8.175 million
Manufacturing of textiles, clothing & leather products	R0.511 million
Manufacturing of wood & paper (products), publishing and printing	R0.895 million
Manufacturing of chemicals, rubber & plastic products	R4.161 million
Manufacturing of metal products, machinery & equipment	R1.595 million
Manufacturing of electrical & optical equipment	R3.291 million
Manufacturing of transport equipment	R17.744 million
Manufacturing of furniture & n.e.c.	R0.444 million
Wholesale	R1.604 million
Transport and communication	R8.732 million
Financial intermediation	R 8.714 million
Business services	R 2.218 million
Total	R 3.563 million

In 2000, a South African firm in manufacturing and services spend on average about R 3.6 million on R&D and non-R&D related expenditures. As can be expected, because for example average firm sizes differ between sectors, considerable variations between the sectors were observed. Firms in the transport equipment industry invested an average of R 17.7 million in innovation, whereas for firms in the manufacturing of furniture & other manufacturing an average of R 0.44 could be noted.

Table 5.9 shows the total average innovation expenditures 2000 in million ZAR per size class.

Table 5.9: Total average innovation expenditures 2000 per firm, in million ZAR, by size class

Size class	Total innovation expenditures 2000
< 50 employees	R 0.988 million
50 to 250 employees	R 3.742 million
250 to 500 employees	R 9.458 million
> 500 employees	R 54.107 million
Total	R 3.563 million

Firms with less than 50 employees invested in 2000 an average of R 0.99 million. The larger the firm, the higher the average amount of money invested is. Firms with 500 or more employees were able to spend an average sum of R 54.1 million on innovation expenditures.