Research design for the South African innovation survey 2001

Eindhoven Centre for Innovation Studies, The Netherlands

Working Paper 01.02

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L.A.G. Oerlemans, A.J. Buys & M.W. Pretorius

Faculty of Technology Management

Eindhoven University of Technology, The Netherlands

April 2001

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L.A.G. Oerlemans
Department of Technology and Policy
Faculty of Technology Management
Eindhoven University of Technology
The Netherlands

A.J. Buys
Institute for Technological Innovation
University of Pretoria
South Africa

M.W. Pretorius
Department of Engineering and Technology Management
University of Pretoria
South Africa

Abstract. *The University of Pretoria in close cooperation with the Eindhoven University of Technology has decided to conduct a South African Innovation Survey in 2001. The purpose of the survey is twofold; firstly, to get a representative, nationwide picture of the innovative behaviour and performance of South African firms in manufacturing and services, and secondly, to compare the South African situation on innovation to the European one. The South African Innovation Survey will be modelled on the European Community Innovation Survey (CIS) conducted in European Union countries. This paper describes the proposed research design and modifications to the CIS questionnaire to suit the South African environment.*

Keywords: Innovation, Survey, Sampling, Questionnaire

1. Introduction and research question

1.1 Introduction

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. 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. The main flaw in these surveys is that they use only a few indicators, measuring often only inputs to the innovation process. 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 hopefully 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 is the first time that a harmonised business survey has 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.

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.

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. Although the type of information required to calculate an *innovation productivity index* (innovation output ÷ innovation input) was obtained, such a calculation was not attempted. The SISAMF-1996 therefore doesn't 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 98. 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.

An innovation survey should also be extended and repeated at regular intervals. 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 a 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 currently involved in a joint research project that includes an Innovation Survey in South Africa in 2001. It is the aim of this paper to describe a number of methodological issues related to the South African Innovation Survey 2001 (SAIS 2001) and to describe the variables that will be used to measure innovation activities.

This paper is structured as follows. In the remaining part of Section 1 the research goals and the research question of the survey are formulated. Next, some notes on the theoretical framework of the research project are put forward. Section 2 discusses the research design of SAIS 2001, including topics like population and sampling strategy. In Section 3, the research instrument, i.e. the questionnaire that will be used, is described. This section provides an overview of the way innovative behaviour of South African firms will be measured.

1.2 Research goals and research question

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 this research project:

To what extent did South African firms in manufacturing and services conduct innovative activities in the period 1998-2000?

1.3 Theoretical framework

It is our belief that empirical research should be grounded on a sound theoretical framework. In this section we discuss briefly the theoretical framework that was used as the basis for the development of the research instrument.

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. 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 uncodified, 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 their 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: 793) who state that "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: 1120-1121), "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.

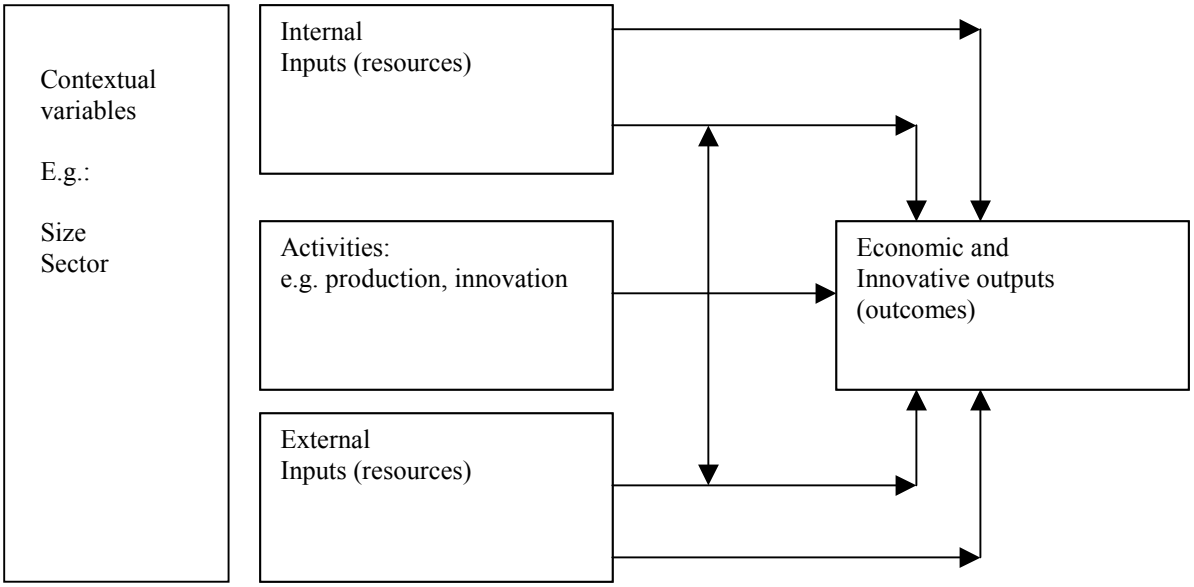
As a consequence, we have to define the technological innovation processes in Håkanssonian terms. Technological innovation is a *transformation* activity where an *actor,* through the (re)combination of heterogeneous *resources,* develops and introduces new or improved products/services or production processes with the expectation of better economic performance. Within firms, innovation is conceptualised as an open system (Katz & 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 depicts this model.

Figure 1: Research model



In the last section of this paper we will position the indicators to measure innovation according to the model depicted in figure 1.

2.2 Research design

2.1 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[1] *that conducted economic activities in the period 1998-2000.*

With this 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 Kompass 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.

Classification of economic activities In order to obtain full compatibility with the Community Innovation Survey (hereafter: CIS) of the European Community the following economic sectors (General Industrial Classification of Economic Activities within the European Communities [NACE]) should be included:

[1] *In most researches, the 10 employee-boundary is used. The main reason for this is the practical experience that a relatively high non-response rate is obtained when surveying firms with less than 10 employees.*

D	Manufacturing
DA	Manufacture of food products, beverages and tobacco
DB_DC	Manufacture of textiles and textile products; manufacture of leather and leather products
DD_DE	Manufacture of wood and wood products, manufacture of pulp, paper and paper products; publishing and printing
DF_DG	Manufacture of coke, refined petroleum products and nuclear fuel, manufacture of chemicals, chemical products and man-made fibres
DH_DI	Manufacture of rubber and plastic products, manufacture of other non-metallic mineral products
DJ	Manufacture of basic metals and fabricated metal products
DK	Manufacture of machinery and equipment n.e.c.
DL	Manufacture of electrical and optical equipment
DM	Manufacture of transport equipment
DN	Manufacturing n.e.c.
E	Electricity, gas and water supply

G_TO_Q	Services
G51	Wholesale trade and commission trade, except of motor and motorcycles
I60_TO_I62	Land transport; transport via pipelines; water transport; air transport
I642	Telecommunications
J	Financial intermediation
K72	Computer and related activities
K742	Architectural and engineering activities and related technical consultancy

Size classes In CIS publications, the use of size classes is dependent on the sector, i.e. manufacturing or services. For the manufacturing sector, CIS uses the following classification:

Size Class	Description
20_49M	Small enterprises (manufacturing sector)
50_249M	Medium-sized enterprises (manufacturing sector)
250M_MORE	Large enterprises (manufacturing sector)

For the service sector:

Size Class	**Description**
10_49S	Small enterprises (service sector)
50_249S	Medium-sized enterprises (service sector)
250S_MORE	Large enterprises (service sector)

In CIS the lower boundaries for the two sectors differ. Since the South African economy (as the Dutch economy) is characterised by a large number of small enterprises in manufacturing and services, we will use the same lower boundary for both sectors, i.e. for both sectors firms with 10 or more employees will be included in the sample. This approach was followed in the Dutch versions of the CIS[2] also.

2.2 Sampling techniques and sample size

2.2.1 Sampling techniques

Techniques that make use of probability theory can both greatly reduce the chances of getting a non-representative sample and, what is more important, permit precise estimation of the likelihood that a sample differs from the population by a given amount. In these so-called probability samples, each element has some chance of being included in the sample, and the probability of each element's being included can be determined.

[2] *Centraal Bureau voor de Statistiek (1998), Kennis en Economie 1998. Onderzoek en Innovatie in Nederland. CBS, Voorburg/Heerlen, December 1998, p. 52. E. Brouwer, A. Kleinknecht (1994), Innovatie in de Nederlandse Industrie en Dienstverlening (1992). Ministerie van Economische Zaken, Beleidsstudies Technologie Economie 27, Den Haag, 1994, p. 15.*

Furthermore, probability samples enables one to calculate *sampling error*, which is the extent to which the values of the sample differ from those of the population from which it was drawn.

There are a many types of probability samples like 'simple random sampling', 'systematic sampling' and 'area sampling'. For the purposes of the SAIS 2001 *stratified sampling* is an adequate sampling technique.

With simple random and systematic sampling methods, the target population is treated as a unitary whole when sampling from it. Stratified sampling changes this by dividing the population or the sampling frame into smaller subgroups, called strata, prior to drawing the sample, and then separate random samples are drawn from each of the strata. One of the major reasons for using a stratified sample is that stratifying has the effect of reducing sampling error for a given sample to a lower level than that of a simple random sample of the same size. This is so because the more homogeneous a population on the variables being studied, the smaller the sample size needed to represent it accurately. Stratifying makes each sub-sample more homogeneous by eliminating the variation on the variable that is used for stratifying.

In fact, when stratification is used for reducing sampling error, *proportionate stratified sampling* is normally used, in which the size of the sample taken from each stratum is proportionate to the stratum's presence in the population.

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

- 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.

2.2.2 Sample size

A key issue in selecting a sample is that it *represents* the population from which it was drawn. It is often assumed that a larger sample is more representative than a smaller sample, and thus one should go for the largest sample possible. Actually, deciding on an appropriate sampling size is more complicated than this. Five factors influence the sample size; (1) the research hypotheses; (2) the level of precision; (3) the homogeneity of the population; (4) the sampling fraction; (5) the sampling technique used.

Research Hypotheses One concern in establishing desired sampling size is that there are a sufficient number of cases to examine research hypotheses properly. If one has, for example, 3 variables with 3 values each then a simple cross tabulation would require 27 cells. For proper testing, each cell should be filled with a minimum of cases (e.g. 10). Generally the literature considers 100 cases in a sample the bare minimum.[4]

Level of Precision The second factor influencing sample size is the level of precision, or in other words the level of sampling error[5] one is willing to accept in a research. Suppose the average R&D effort of firms in a country is 6.5%. A sample of 200 firms is drawn and the average R&D effort is calculated as 6.2%. As one can see the sample statistic is close to the population statistic, but there is an error of 0.3% points (the sampling error).

In reality, the sample statistic is known but the population statistic is unknown. So, the question is how the difference between the sample and the population value can be assessed. The answer to this question is that this assessment can be done in terms of the likelihood that a sample value differs by a certain value from the population value. Establishing a confidence interval, i.e. a range in which it is fairly certain that the population value lies, does this.

Moreover, precision is directly related to sample size. Larger samples are more precise than smaller ones. Probability theory enables to calculate the sample size that would be required to achieve a given level of precision. The table shown below illustrates this.

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[3] *This way of sampling is in concordance with the approach used in the Dutch CIS 1998.*

[4] *D.R. Monette, T.J. Sullivan, C.R. DeJong (1990), Applied Social Research. Tool for the Human Sciences. Harcourt Brace Jovanovich College Publishers, Orlando, p. 146.*

[5] *Sampling error is the difference between a sample value of a variable and the population value of the same variable.*

Table 1: Simple Random Sample Size for Different Degrees of Precision[6] for a Population of 16,931.

Tolerated Error	**Confidence Level**	
(Confidence Interval)	*95%*	*99%*
1%	9,604	16,587
2%	2,401	4,147
3%	1,067	1,843
4%	600	1,037
5%	384	663
6%	267	461
7%	196	339

It can be derived from the table that for example with a sample of 9,604 cases, there is a 95% probability that the sampling error is 1 percent or less. In other words, there is a 95% chance that the sample value is within 1% of (above or below) the population value. In most researches error levels used lie between 2 to 6 percent with 95% confidence limits.

Population Homogeneity The third factor impacting on sample size is the variability of the population to be sampled. As a rule of thumb a large sample is more essential for a heterogeneous population than for a homogeneous one. Unfortunately, most of the time researchers know little about the homogeneity of the target population. Probability theory solves this problem by assuming maximum variability in the population (i.e. 50% variability). Of course, such estimates are conservative and will result in sample sizes larger than strictly needed for a given level of precision.

Sampling Fraction A fourth factor influencing sample size is the sampling fraction, which can be defined as the number of elements in the sample relative to the number of elements in the population (n/N). However, with large populations such as the one used for SAIS 2001, the sampling fraction issue can be ignored because the sampling fraction will constitute only a small fraction of the population by definition. For large samples, the research hypotheses, sampling error, and population homogeneity are most of the times sufficient to determine sample size.

Sampling Technique The final factor influencing sample size is the sampling technique employed. Some sampling techniques, like 'simple random sampling' and 'area sampling', tend to increase sampling error. One of the main characteristics of the sampling technique that will be used in the SAIS 2001, stratified sampling, is that it tends to reduce sampling error and decreases the required sample size.

Estimating sample size for stratified samples is relatively complex because the effects of stratifying on sampling error varies from one sample to another depending on the number of stratification variables, homogeneity of samples and the like. Accurate estimates, however, can be calculated. Scheaffer, Mendenhall and Ott (1979) provide the necessary information to calculate sample size when using a stratified sampling technique.[7]

2.2.3 Determining sample size for SAIS 2001

Defining strata Since we aim at high comparability with the European CIS, we took basically the same sample design approach as in CIS. By implication, this means that three strata were defined (stratum 1: firms with 11 to 20 employees; stratum 2: 21-50 employees; stratum 3: more than 50 employees), taking the number of employees as the stratification variable (see below). There are two reasons for using this variable:

1. A theoretical one: It is well known that innovative efforts differ considerably between size classes (Brouwer and Kleinknecht, 1994, 1996);
2. A practical one: the number of employees is the only quantitative variable in the South African Reed database. Because one needs population information like standard deviation and variance to compute strata size, it is inevitable to use this variable;

Ideally, one wants to stratify on sector also. An attempt was made to do this with the Reedbase, but two problems were encountered. The first problem had to do with the differences in classification schemes of economic activities used in Reedbase Kompass and CIS 98 (i.e. the NACE Rev. 1). After a detailed study of both classifications schemes, it was possible to make the classifications exchangeable.

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[6] *Source: C.H. Backstrom, G.D. Hursh (1981), Survey Research. Macmillan Press, p. 75.*

[7] *R.L. Scheaffer, W. Mendenhall, L. Ott (1979), Elementary Survey Sampling. Duxbury Presss, Massachusetts, USA, pp. 59-98.*

The second problem is a result of the way firms' activities are classified in the Reedbase Kompass. As a first step, stratified sampling frames were drawn from Reedbase Kompass. Nine strata were constructed, each stratum containing one of the three size classes and one of the three activity groups (producer, distributor and service). Next, the strata were compared. It was found that the strata had unacceptable levels of overlap, i.e. a number of firms were included in 2 or even in 3 strata, which means that firms are entered in the Reedbase under more than one economic activity. The percentages of overlap ranges from 2% to almost 8%. The consequence of this overlap is that firms have differing probabilities on being selected in a sample and sampling frames are not independent, which is a necessary condition for stratified sampling. Consequently, it was decided only to stratify on size.

Selecting Sample Size In this section, a method of choosing the sample size to obtain a fixed amount of information for estimating a population parameter is examined. It is specified that the estimate of the population average (y_{st}) should lie within B units of the population mean, with probability approximately equal to 0.95. This means that:

$$(1) \quad 2\sqrt{V(y_{st})} = B$$

or

$$(2) \quad V(y_{st}) = \frac{B^2}{4}$$

where y_{st} denotes the estimator of the population mean, $V(y_{st})$ denotes the estimated variance of y_{st}, and B denotes the error of estimation. Although $V(y_{st})$ is defined, n cannot be found unless a relationship is postulated among n_1, n_2, …..n_L and n. In any case, the number of observations n_i allocated to the ith stratum is a fraction of total sample size n. This can be denoted as w_i. Hence one can write

$$(3) \qquad n_i = nw_i \qquad i = 1,.....,L$$

Using this relationship, one can set $V(y_{st})$ equal to $B^2/4$ and solve for n.
As a result the approximate sample size required to estimate population mean or total with a bound B on the error of estimation is:

$$(4) \qquad n = \frac{\sum_{i=1}^{L} \frac{N_i^2 \sigma_i^2}{w_i}}{N^2 D + \sum_{i=1}^{L} N_i \sigma_i^2}$$

where w_i is the fraction of observations allocated to stratum i, σ_i^2 the population variance for stratum i, and N is the number of sampling units in the population. Moreover, when estimating μ (population mean):

$$(5) \quad D = \frac{B^2}{4}$$

Allocation of the sample The objective of a sample survey design is to provide estimators with small variances at the lowest possible costs. After a sample size (n) is chosen, there are many ways to divide n into the individual stratum sample sizes n_1, n_2, ……, n_L. Hence the objective is to use an allocation that gives a specified amount of information at minimum cost. The best allocation scheme is influenced by three factors:

1. The total numbers of elements in each stratum;
2. The variability of observations within each stratum;
3. The cost of obtaining an observation from each stratum.

Scheaffer, Mendenhall & Ott (1979: 69) state that the approximate allocation that minimizes cost for a fixed value of the variance of the population mean $V(y_{st})$ or minimizes $V(y_{st})$ for a fixed cost is:

$$(6) \qquad n = \frac{\left[\sum_{k=1}^{L} N_k \sigma_k / \sqrt{C_k}\right]\left[\sum_{i=1}^{L} N_i \sigma_i \sqrt{C_i}\right]}{N^2 D + \sum_{i=1}^{L} N_i \sigma_i^2}$$

where N_i denotes the size of the ith stratum, σ_i^2 denotes the population variance for the ith stratum, and C_i denotes the cost of obtaining a single observation from the ith stratum.

In some stratified sampling problems, the cost of obtaining an observation is the same for all strata. It is assumed here, that this is the case in SAIS 2001. Formula (6) can still be used by letting $C_L = 1$. When $C_1 = C_2 = \ldots\ldots = C_L$ and $w_1, w_2, \ldots.., w_L$ are obtained by formula 6, the method of selecting the proportion of the sample size n to be assigned to each stratum is called *Neyman allocation*, which will be applied here.

Calculating sample and strata size Now all necessary tools are available to calculate sample and strata size for SAIS 2001. As a first step, sample frames were drawn from Reedbase Kompass, selecting producers, distributors, and service firms in the economic activity categories described above and stratified according to the formulated size classes. Table 2 describes some features of the strata

Table 2: Stratum size, mean, standard deviation and variance

Stratum	N_i	Mean	Stand. Dev	Variance
11-20 employees	2166	15.99	3.19	10.16
21-50 employees	4611	35.04	7.12	50.67
More than 50	3665	769.59	3337.32	11135569

As in CIS 98, all firms with more than 50 employees will be selected and approached with a questionnaire. Consequently, it is not necessary to determine sample size for this stratum.

The formulas (4) and (6) will be used to calculate sample sizes. It is assumed that costs are the same in the two remaining strata. Therefore, to find the allocation fractions, w_1 and w_2, the costs are replaced by 1 in formula (6). Then:

$$\sum_{i=1}^{2} N_i \sigma_i = N_1\sigma_1 + N_2\sigma_2 + N_3\sigma_3$$

$$= (2166)\ (3.19) + (4611)\ (7.12) = 39{,}739.86$$

and from formula (6)

$$n_1 = n\left[\frac{N_1\sigma_1}{\sum_{i=1}^{2} N_i\sigma_i}\right] = n\left[\frac{6909.54}{39{,}739.86}\right] = n\ (0.173869258)$$

Similarly,

$$n_2 = n\left[\frac{32.830{,}32}{39{,}739.86}\right] = n(0.826130741)$$

Thus $w_1 = 0.173869258$ and $w_2 = 0.826130741$.

Now one can use formula (4) to find n. A bound of 0.2 employees on the error of estimation means that

$$D = \frac{B^2}{4} = \frac{0.2^2}{4} = 0.01 \qquad and \qquad N^2 D = \left(6777^2\right) * 0.01 = 459.277.29$$

Also

$$\sum_{i=1}^{2} \frac{N_i^2 \sigma_i^2}{w_i} = \frac{\left(2166^2\right)\left(3.19^2\right)}{0.173869258} + \frac{\left(4611^2\right)\left(7.12^2\right)}{0.826130741} = 1{,}579{,}256{,}474$$

And

$$\sum_{i=1}^{2} N_i \sigma_i^2 = (2166)\ (3.19^2) + (4611)\ (7.12^2) = 255{,}793.311$$

From formula (4),

$$n = \frac{\sum_{i=1}^{2} \frac{N_i^2 \sigma_i^2}{w_i}}{N^2 D + \sum_{i=1}^{2} N_i \sigma_i^2} = \frac{(1{,}579{,}256{,}474)}{(459{,}277.29) + (255{,}793.311)} = 2{,}208$$

Hence,

$$n_1 = (0.173869258)\,(2208) = 384 \quad and \quad n_2 = (0.826130741)\,(2208) = 1824$$

In order to get these numbers of observation after surveying, one has to take non-response into consideration. Estimating the non-response percentage is always an educated guess because researchers do not know in advance which factors impact on response rate at a specific moment in time and space. Looking at past experiences, non-response ratios differ widely. For example, in the Dutch CIS 92 the overall response rate was approximately 53%, whereas in CIS 98 a much higher overall percentage was obtained (73%). In the most recent South African innovation survey, however, response rates were much worse (ca. 10%).

For SAIS 2001, it is expected that response rate will vary between 50% (for the smaller firms) and 70% (for the larger firms). There are two main reasons for these expectations:

- The SAIS 2001 questionnaire is based on the CIS 98 questionnaire, which is a well designed, widely used, and thus well-tested questionnaire. Moreover, this questionnaire has proven its usability in practice;
- At first, firms will be approached with a postal questionnaire. If they do not respond within a time frame of 3 weeks, the non-responding firms will be approach by telephone. Following this procedure, it is expected that response rates can be increased considerably.

With these considerations in mind, sample sizes for SAIS 2001 can be determined. In Table 3, the sample size is presented:

Table 3: 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

3. The research instrument for the SAIS 2001

3.1 Introduction

As was stated in section 1, the purpose of the SAIS 2001 is twofold. First, it is the aim to get a representative, nationwide picture of the innovative behaviour and performance of South African firms in manufacturing and services. Second, we want to compare the South African situation on innovation to the European one. It is therefore necessary to use a research instrument, in this case a questionnaire that meets these purposes.

It was decided to use the Community Innovation Survey 1998 (hereafter: CIS 98) as the basis for the SAIS 2001.[8] For a number of reasons, CIS 98 was not fully applicable to the South African situation. First of all, CIS 98 had a number of questions, which were not usable in South Africa. A clear example of this is the question on the location of R&D partners, which uses geographical dimensions for the European scale. Of course, because of the size of South Africa such a question had to be adapted to South African geographical dimensions. Second, CIS 98 is somewhat biased towards innovative firms. Early in the CIS 98 questionnaire, non-innovators are referred to the last page of the questionnaire. As a result, a lot of information on these non-innovators is not gathered. Because we are also interested in information on South African non-innovators, a number of questions in CIS 98 are moved to other positions in the questionnaire. Third, we added a number of new questions.

As a consequence of the issues raised above, this section discusses the way the SAIS 2001 questionnaire was constructed. In section 3.2, the CIS 98 questions that did not change in SAIS 2001 are presented. Next in section 3.3, we discuss the questions that were adapted to the South African Situation. Section 3.4 goes into the repositioned questions, whereas the newly constructed questions are presented in section 3.5.

CIS 98 used separate questionnaires for the manufacturing and service sector. It turned out that this was not possible for SAIS 2001, because in the Reedbase some firms are listed as manufacturer and at the same time as a service provider. Sending questionnaires intended for manufacturing firms to for example service providers will probably increase non-response. To avoid this we decided to use one questionnaire for all firms. The SAIS 2001 questionnaire can be found in Appendix I.

3.2 Unchanged questions in SAIS 2001

In this section, an overview is presented of the questions in CIS 98, which could be used without adaptations in SAIS 2001. You can find this overview in Table 4.

In order to obtain maximum comparability, most questions in CIS 98 are also used in SAIS 2001. However, as will be explained in section 3.4, some of these unchanged questions are moved to another position in the questionnaire. The unchanged questions do not need further clarification, as they speak for themselves.

The unchanged questions are:
- Q0: items on financial consolidation, affiliation, and location of head office;
- Q2a: Innovated products/services;
- Q2b: Innovated processes;
- Q6: Product and/or service innovation sales;
- Q8a: Innovation and the use of external information sources;
- Q10: Objectives of innovation.

[8] *Drs. J. Pronk of the Dutch Central Bureau of Statistics kindly provided copies of the CIS 1998 questionnaire.*

Table 4: Composition of the SAIS 2001 questionnaire

# Q	Topic	Nature of change	# Q CIS 98
0	**General Information**	Part 1: U Part 2: U, M	Part 1: Q 0 Part 2: Q 11/14
1a	**Business Activities: Marketing, distribution, sale**	N	n.a.
1b	**Business Activities: Production**	N	n.a.
1c	**Business Activities: Transferring or selling technology**	N	n.a.
2a	**Manufacturing: Innovated products** **Services: Innovation**	U U	Q 1a Q 1a
2b	**Manufacturing: Innovated processes** **Services: Innovation and technology**	U U	Q 1b Q 1b
2c	**Innovative activities**	U	Q 1c
3a	**Own research and/or development (R&D)**	A, M	Q 8a /Q 8b
3b	**Innovation expenditures 2000**	U, M	Q 8a
4a	**Innovation and bottlenecks**	N	n.a.
4b	**Factors hampering innovation**	U, M	Q 9
4c	**No technological innovative activities**	U, M	Q 12
5	**Innovation in a broader sense**	U, M	Q 10/Q 13
6	**Innovation and sales**	U	Q 12
7	**Innovation and market position**	A	Q 3
8a	**Innovation and the use of external information sources**	U	Q 4
8b	**Innovation and the use of internal information sources**	A, N	Q 4
9	**Innovation in partnership: partners in South Africa**	A	Q 5
10	**Objectives of innovation**	U	Q 7
11	**Innovation in partnership: foreign partners**	A	Q 5
12	**Innovation funds**	A	Q 6
13a	**Characteristics of service/product innovation**	N	n.a.
13b	**Characteristic of process innovations**	N	n.a.
14a	**Technology strategy**	N	n.a.
14b	**Training in Technology and Innovation Management**	N	n.a.
14c	**Person for Technology Management**	N	n.a.
14d	**Technology and Innovation Management Tools**	N	n.a.
15a	**Internal consequences of service/product innovation**	N	n.a.
15b	**Internal consequence of process innovation**	N	n.a.
16	**Level of specialisation**	N	n.a.
17	**Level of education**	N	n.a.
19	**Organisational structure**	N	n.a.

Q = Number of Question in SAIS 2001
Nature or change: U = Unchanged; M = Moved, A = Adapted, N = New
Q CIS 98: Number of question in CIS 98; n.a. = not applicable

3.3 Adapted questions in SAIS 2001

The structure of the South African economy and the characteristics of the country differ significantly from the European situation. In terms of GDP[9], for example, the South African economy is characterised by a relatively large primary sector (agriculture, mining), although the contribution of this sector to total GDP is clearly declining in recent years. Between 1990 and 1995, the contribution decreased from 13.8% to 10.8%.

For SAIS 2001, especially manufacturing and parts of the tertiary sector are of importance. In 1995, manufacturing's GDP was almost 28% of total value added (1990 = 30.9%). This decrease is caused by a number of factors, including skilled labour shortages, complex competitiveness problems and a high dependency on foreign technology[10]. By contrast, the contribution of the services sector to total value added rose from 55.5%

[9] *Source: J.W. Prinsloo (2000), Revision of South Africa's national account. Http://www.resbank.ca.za. Figures at basic prices.*

[10] *Business Monitor International (1995), South Africa 1995-97. Annual Report on Government, Economy, the Business Environment and Industry, with Forecasts through end-1997, London.*

in 1990 to 61.5% in 1995. This increase stemmed mainly from higher output levels by the transport and communication sectors, business services and the general government.

These findings stress on the one hand the fact that it is important to include the services sector in the survey, while on the other hand one can expect that the *research* capabilities of South African firms are relatively low in comparison to their *development* capabilities, since South African firms in general are more used to applying and improving production technology, rather than developing their own product and process technology. By implication, this means that some CIS 98 questions have to be adapted, stressing more the development side of innovation, than the research side.

Another reason for adapting some questions in CIS 98 has to do with the different geographical scale of South Africa compared to a number of European countries.

The following questions have been adapted:

Question 3a. Own research and/or development (R&D) First of all, this question has been moved to a position in the questionnaire so that innovators as well as non-innovators have to answer the question. Moreover, the intramural R&D item in CIS 98 Q8a has been combined with the CIS 98 question on intramural research (Q8b). The item on the location of R&D in CIS 1998 (in one or more than one province) has been dropped since this item is already surveyed in SAIS question 9. As a result SAIS Q3a includes: (1) an estimate of the R&D effort in persons and in man-years; (2) an estimate of the related innovation costs 2000; (3) the accuracy of the estimate of R&D innovation costs 2000; (4) the structural character of R&D in the firm.

Question 7. Innovation and market position In CIS 98, the item on innovation and market position had an asymmetrical scale and a bias towards improvement of market position due to innovation. In SAIS 2001, a 5-point symmetrical scale is used ranging from (1) worsened substantially to (5) improved substantially.

Question 8b. Innovation and the use of internal information sources The use of internal information sources for the innovation process was in CIS 98 limited to 1 item in Q4 asking on 'innovation ideas from your own firm'. Since many firms in South Africa do not have a stand-alone R&D function but still innovate, it is important to find which other firm functions possibly influence the innovation processes. Moreover, recent research (Oerlemans, Meeus & Boekema, 1998) showed that contributions from internal functions to the innovation process other than the R&D function were influential[11]. As a result, we constructed a question on the use and importance of internal functions as a source of information in the innovation process. We distinguished 6 internal functions: purchase, marketing/sales, research, development, engineering, and production.

Question 9. Innovation in partnership: partners in South Africa In CIS 98 there was one question on innovation in partnership. The answering categories of this question were suitable for the European geographical situation and not for the South African situation. Moreover, for foreign partners CIS 98 did not specify country or region in which a foreign partner is located, it only asks for the geographical distance between a responding firm and its foreign partner.

For SAIS 2001, it was decided to construct two questions dealing with innovation partners. One question on partners located in South Africa and one question on foreign partners (see the discussion on question 11). With regard to the question on innovation partners located in South Africa, the same items (= partners) were used as in CIS 98, that is: own group, buyers, suppliers, competitors, consultants, research institutes, universities, and other partners. Three answering categories were used: (1) Own town/city; (2) Own province, and (3) Other provinces.

Question 11. Innovation in partnership: foreign partner Question 11 is basically the same question as question 9, but now the answering categories are referring to partners located in countries and regions outside South Africa. These categories are: SADC, other African countries, Europe, North America, South America, and Asia/Australia. A footnote has been added explaining the composition of the Southern African Development Community

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G. de Wet (1999), Emerging from the Technology Colony: A View from the South,. Department of Engineering and Technology Management, University of Pretoria, South Africa. Working Paper ITB2001/1.
World Economic Forum (2000), The Global Competitiveness Report 2000, Geneva, Switzerland.

[11] *Oerlemans, L.A.G., M.T.H. Meeus, F.W.M. Boekema (1998), Do Networks Matter for Innovation? The usefulness of the economic network approach for analysing innovation. In: Journal of Economic and Social Geography.*

Question 12. Innovation funds In CIS 98 it was asked whether or not firms received a subsidy to develop innovations. Moreover, firms could indicate the origin of these subsidies. In SAIS 2001, the question was somewhat extended including not only subsidies but also other innovation funds. Of course, subsidies and funds were included which are applicable to South African firms, such as THRIP (Technology and Human Resources for Industry Programme), Innovation Fund, Support Programme for Industrial Innovation, the Sector Partnership Fund, the Competitive Fund, and Development Capital.

3.4 Re-positioned questions in SAIS 2001

In comparison with CIS 98 some questions were positioned in another location in the SAIS 2001 questionnaire. Most questions in CIS 98 are aimed at firms with product, service or process innovations, neglecting the possibility that firms show innovative activity without producing an innovation e.g. because the innovation project failed or was terminated for some other reason. Because we are also interested, especially for policy reasons, in this group of firms, we moved a number of questions to a position in the questionnaire which makes it possible to measure innovative activity of firms that have not realised innovative output. It concerns the following questions:

- Q0: items on number of employees in 1998 and 2000; total sales in 1998 and 2000; export ratio in 1998 and 2000; establishment of the firm between 1998 and 2000; whether or not the firm bought or sold a firm between 1998 and 2000; the influence of buying and selling firms on total sales;
- Q3b: Innovation expenditures;
- Q4b: Factors hampering innovation;
- Q4c: No technological innovations (main reasons for not innovating);
- Q5: Innovation in a broader sense (non-technological innovations);

3.5 New questions in SAIS 2001

In comparison to CIS 98, a number of new questions have been added to SAIS 2001 especially derived from activity-based theory. There are several reasons to include these new questions. First, CIS 98 has a bias towards inputs and outputs of the innovation process, neglecting the so-called throughput of the innovation process. Most innovation research assumes that resources (inputs) like R&D are a sufficient means to produce innovative outputs. It is our view, as was explained in section 1, that having resources is not enough to realise innovative outcomes. It is also the way these resources are utilised and managed in innovation processes in organisations which determines whether efficient and effective outcomes are realised. Both utilisation and management are organisational activities and are as such typical throughput concepts.

Second, and closely related to the first issue discussed above, innovation literature suggests (B-A. Lundvall, 1992) a link between the complexity of innovative activities and the need for and the acquisition of external knowledge. We define the complexity of innovative activities in terms of the innovator firm's nature of innovative activities and the internal consequences of innovations. More drastic innovative activities and more drastic internal consequences of these activities indicate higher levels of complexity. The relationship between complexity of innovative activities and the external acquisition of knowledge and information, as suggested by Lundvall, runs as follows. More complex innovative activities draw more heavily on a firm's internal resources. As a result, there is a higher probability that these internal resources are not sufficient to produce the innovations. Moreover, complex innovations erase existing communication codes between users and producers. New codes have to be developed on a trial and error basis, which requires intensive interactions between users and producers (Lundvall 1992: 58). In sum, internal resource deficits and/or changing communication codes indicate complex innovative activities and ask for interaction with external partners. On the basis of this line of reasoning we decided to include a number of questions measuring features of (the complexity of) innovative activities.

Third, the growing strategic importance of technology-based competition coupled with rapid technological changes make the ability to manage the process of technological innovation an essential skill that companies need to compete. This activity encompasses five major categories: managing the acquisition, development and deployment of technology; managing technologically complex processes; using technology for competitive advantage; managing the interactions between technology and the organisation; and addressing the impact of technology on technology itself, as well as on different aspects of society. Since there is a growing awareness that technology and innovation must be managed in a formal and strategic way, we developed a number of questions measuring the extent in which companies conduct activities and use tools related to the management of technology and innovation.

Complexity can be measured at several levels. We included measures of complexity for two levels in the questionnaire: the organisational complexity and complexity of innovative activities. The following measures have been developed and included in SAIS 2001 to measure complexity (of innovative activities):

Measuring organisational complexity:

Founded on literature (Dewar & Hage, 1978; Dewar, Whetten & Boje: 1980) on organisational complexity, we developed the following indicators measuring dimensions of organisational complexity.

Question 16. Level of specialisation Firms are asked to indicate which percentage of all employees is considered as highly trained specialists.

Question 17. Level of education Firms are asked to indicate which percentage of all employees is educated on tertiary level.

Question 18. Organisational structure Firms are asked to indicate how many levels there are under the top management level.

Measuring the complexity of innovative activities:

Taking Lundvall's ideas on the complexity of innovative activities as a point of departure, we developed the items listed below to operationalise the complexity of innovative activities.

Question 13a. Characteristics of product/service innovation Firms are asked to characterise their innovative activities aimed at the realisation of product or service innovations. Three possible answers are provided: (1) step by step changes of products/services; (2) drastic changes of products/servers; (3) no products/services innovated. The first possibility indicates incremental innovative activities, while the second possibility denotes radical activities. The question is an operationalisation of the complexity of innovative activities.

Question 13b. Characteristics of process innovation Firms are asked to characterise their innovative activities aimed at the realisation of process innovations. Three possible answers are provided: (1) step by step changes of processes; (2) drastic changes of processes; (3) no processes innovated. The first possibility indicates incremental innovative activities, while the second possibility denotes radical activities. The question is an operationalisation of the complexity of innovative activities.

Question 15a. Internal consequences of product/service innovations Firms are asked to indicate on a scale from 1 to 5 to what extent product/service innovations caused changes of other products, services and processes within the firm. Possibilities to answer range from 1 (no changes) to 5 (drastic changes). This item measures the complexity of innovative activities.

Question 15b. Internal consequences of process innovations Firms are asked to indicate on a scale from 1 to 5 to what extent process innovations caused changes of other products, services and processes within the firm. Possibilities to answer range from 1 (no changes) to 5 (drastic changes). This item measures another aspect of the complexity of innovative activities.

Measuring the management of technology and innovation:

As was stated in Section 1, innovative activities have to be managed, just as other organisational activities. To measure several aspects of the management of technology and innovation in firms, the following items were developed:

Question 14a. Technology strategy With this question it can be determined whether or not a firm has a formal technology strategy.

Question 14b. Training in Technology and Innovation Management Firms are asked to indicate whether or not recent knowledge on technology and innovation management is acquired through attending courses on this topic.

Question 14c. Person for Technology Management Firms are asked to indicate whether or not a specific person in the firm is responsible for the management of technology. Moreover, if this is the case the management level of this person is determined.

Question 14d. Technology and innovation management tools Firms are asked to indicate whether or not they use a number of technology and innovation management tools to manage their innovation processes. The items are grouped in three categories: (1) instruments and tools aimed at monitoring and forecasting technological development; (2) instruments and tools aimed at the analysis of the business environment; and (3) instruments and tools aimed at the monitoring and management of technology and innovation at the organisational and project level.

Measuring economic activity:

As was explained in a previous section, we decided to include questions with which it can be determined which economic activities a firm performs. This decision was made because it turned out to be impossible to assign an unique economic activity to a firm in the Reedbase. The following questions were added:

Contact information A respondent is asked to state his name and the telephone number of his/her company.

Most important products/activities/services of your firm Firms are asked to describe their three most important products, activities and/or services.

Main activities It is the aim of this question to identify the main activities of a firm. Possibilities to answer are: (1) Production of (a) consumer goods; (b) raw materials; (c) product parts or components; (d) production equipment; (2) Wholesale of (a) consumer goods; (b) raw materials; (c) product parts or components; (d) production equipment; (3) Transport (services; (4) Communication (services) (5) Financial services, and (6) Business services.

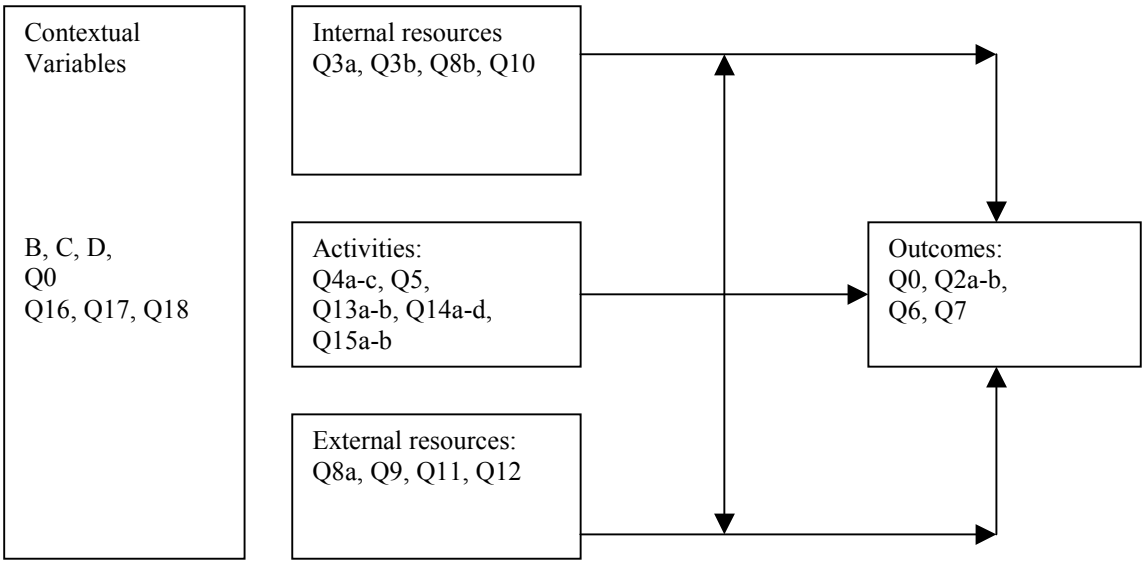
Type of firm Firms are asked to indicate what they consider as their main line of business (manufacturing, service provider, wholesale) in terms of the highest percentage of sales.

Questions 1a, 1b and 1c. Business Activities South Africa has been described as a technological colony (De Wet, 2000). Technological 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 relatively small level of activity in the research end of the life cycle may be present but an insignificant flow of technology from the local R&D community to the local industrial sector takes place. We have therefore decided to include additional questions with which South Africa's position as a technology colony can be measured. Many of the questions already in the questionnaire addresses this issue to some extent, but questions 1a, 1b and 1c were added to obtain a more complete profile of the business activities that companies were engaged in.

4. Conclusion

In this last section, the theoretical model developed in Section 1 is combined with the items included in the questionnaire. In this way, the operationalisations of the different concepts in the model are illustrated.

Figure 2: Operationalisations of the research model



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APPENDIX I

SOUTH AFRICAN INNOVATION SURVEY 2001 FOR MANUFACTURING AND SERVICES

A joint research project of:

University of Pretoria
Department of Engineering and Technology Management
South Africa

Eindhoven University of Technology
Eindhoven Centre for Innovation Studies
The Netherlands

A. Contact information	*Please answer where appropriate*
Name of contact person for your firm: Telephone:	……. ……..
B. Most important products/activities/services of your firm	*Please answer where appropriate*
Please give the three most important products/activities/services of your firm	1……. 2……. 3…….
C. Main activities	*Please, tick where appropriate* *More than one answer possible*
What are the main activities of your firm?	Production of consumer goods Production of raw materials Production of product parts and components Production of production equipment (machines, tools, software) Wholesale business in consumer goods Wholesale business in raw materials Wholesale business in product parts and components Wholesale business in production equipment Transport (services) Communication (services) Financial services Business services (e.g. design, consultancy, engineering, IT service) Other…….
D. Type of firm	*Please, tick only one answer*
Your firm is: *When answering this question, use the activity in which the highest percentage of sales is realised as the criterion*	A manufacturing firm → **Please, read page 3** A service provider → **Please, read page 4** A wholesale business → **Please, read page 4**

DEFINITIONS FOR SOUTH AFRICAN INNOVATION SURVEY 1998-2000 MANUFACTURING

Innovations of products, services and production processes are the result of the development or the use of completely new or recently developed **technologies**, like information technologies, technical sciences or **other technology related** disciplines. These products, services and processes can be labelled as 'technologically new or strongly improved'.

This qualification should be given from the **point of view of your firm**. **Please also include technologically new or significantly improved products introduced by your firm, even though already introduced by one of your competitors**. 'New or improved' is also applicable if your firm started to use already existing production technologies, although other firms already use these production technologies.

Please, do **NOT** included research and development activities in the field of human resources, organisation and/or marketing. Neither include routine variations or 'face lifting' of an already existing product, like for example the introduction of a new brand name.

Innovation

From the point of view of your firm, the technical features of products, services or processes should be improved significantly or completely new in comparison with older, comparable products or processes of your firm

For *processes*, these innovations result for example in lower process costs and/or higher output performance

For *products or services*, there should be a wider range of use for the client and/or the relevant technical product specifications should show significant improvements compared with the specifications of earlier versions.

It should be stressed, that innovation is not only related to doing research. In most businesses **development** of products, services and/or processes, especially done by engineers, is the most important innovative activity. So please **include your development activities** when answering the questions.

Moreover:

The use of strongly improved methods (e.g. using the internet) to distribute already existing products is also considered as innovation.

Some examples:

1. Prototyping of a specific part of a product is considered as an innovative activity, even if only one user/customer is involved.
2. The application of the latest fashion trends in clothing is not considered as an innovative activity, but the use of a strongly improved fabric in an already existing design is.

No innovation:

1. Routine replacement of production equipment by comparable machines.
2. Quality certificates, like ISO. This is no innovation, but if products or processes were technologically new or improved with the aim of certification, this would qualify as an innovation.

Instructions for filling in this questionnaire:

Most questions are fairly easy to answer with just a yes or a no:

To answer this type of questions, just tick as is shown below:

Yes
No

In some questions, it is asked to fill in a figure:

To answer this type of questions, just fill in as is shown below:

……..%

PLEASE GO TO PAGE 5

DEFINITIONS FOR SOUTH AFRICAN INNOVATION SURVEY 1998-2000 WHOLESALES AND SERVICES

In this survey, an '**innovation**' is defined as a *'new or substantially improved'* service, product or process for your firm. Therefore, this definition **includes new or improved services, products or processes already introduced by a competitor.**

Keep in mind that the limitation to a *'new or substantially improved'* service, product and/or process means that its fundamental characteristic is new or significantly improved in relation to the essential characteristics of comparable, earlier services, products or processes. For example, a service/product innovation could imply a much wider range of uses while a process innovation could result in significantly lower costs and/or increased output performances. Furthermore we define:

Technical innovation

This is limited to service, product or process innovations realised thanks to the use of for your firm new or substantially improved applications of **technologies**, such as:

- ✓ Information technology (IT), automation, electronic data processing and communication;
- ✓ Non standard application of mathematics, the use of advanced software tools, data mining;
- ✓ Remaining technologically orientated disciplines as well as new or substantially improved knowledge related to logistics, environment and energy.

Warning:

First a **warning**: The following list of examples does not cover all possible innovations in the service sector. Its purpose is to provide some examples of innovation by using one or more of the above-mentioned technologically orientated knowledge areas.

Examples of service innovation

Electronic payment systems, 24 hour banking client systems, chip cards, instant acceptance short-term insurance by electronic means, advanced systems for extensive data processing, feasibility expert systems for loans (etc), as well as advanced processing tools for registering insurance policies.

Software for optimal stock strategies (zero stock systems), Product data interchange (PDI), electronic ordering systems and/or networks, routing systems, computer-aided logistics, value-aided logistics, integrated networks for information retrieval by trade organisation branches, advanced electronic devices for checking product qualifications, multi-media systems software, software development not based on existing applications or tools, software engineering, tools to link or optimise applications in different software languages, software tools to translate the results of information analyses into formalised software codes (component based technologies), etc.

Innovation is not

Do not include ***non-technologically*** driven innovation, such as fundamental changes in your firm's organisational structure and innovative activities such as marketing and personnel policies. These types of innovation are *only* queried in questions 2a and 5.

Instructions for filling in this questionnaire:

Most questions are fairly easy to answer with just a yes or a no:

To answer this type of questions, just tick as is shown below:

Yes
No

In some questions, it is asked to fill in a figure:

To answer this type of questions, just fill in as is shown below:

……..%

PLEASE GO TO PAGE 5

0. General information *Please, tick where appropriate*

Are your firm's financial results annually consolidated with those of subsidiaries and/or your holding company?	Yes No
Is your firm indirectly affiliated to other firms? (e.g. in a franchise agreement, etc.)	Yes No
Is your firm's head office located in South Africa?	Yes No, head office is located in (name country): ……..

Please, tick or answer where appropriate

	1998	**2000**
Number of employees of your firm in 1998 and 2000?	……	……
Total sales of your firm in 1998 and 2000?	R……	R……
Exports as a % of total sales of your firm in 1998 and 2000?	……%	……%

Was your firm established in the period 1998-2000?	Yes	No
Between 1996 and 1998, did your firm buy another firm?	Yes	No
Between 1996 and 1998, did your firm sell another firm?	Yes	No
Did total sales change with more than 10% as a result of buying and selling firms in the period 1998-2000?	Yes…..	No

1a. Business activities: Marketing, distribution and sale *Please, tick where appropriate*
More than one answer possible

Is your firm involved in the marketing, distribution and sale of products or services?	Yes, of our own products/services Yes, product/services supplied by local supplier Yes, imported No

1b. Business activities: Production *Please, tick where appropriate*
More than one answer possible

Is your firm involved in the production of products and/or the supply of services?	Yes No →**Go to question 1c**
If **yes**, indicate the source of the production technology (technical know-how and techniques)	In-house (proprietary intellectual property) Local sources (local companies or organisations) Foreign sources (e.g. production licenses, etc)

1c. Business activities: Transferring or selling technology *Please, tick where appropriate*
More than one answer possible

Does your firm transfer or sell technology to other firms (production licenses, patents, specifications, etc)	Yes No →**Go to question 2a**
If **yes**, indicate the type of technology supplied:	Marketing, distribution or sales technology Production or processing technology Product technology Technical know-how and techniques (research output)

2a. Innovated products/services

Please, tick where appropriate
More than one answer possible

Between 1998-2000, has your firm introduced products and/or services onto the market technologically **improved** or **new** to your firm?

***Improved**: an existing product/service which has clearly improved technical specifications or an increased usability, compared to previous versions.*

***New**: a product/service incomparable with previous products or services of your firm and in which new technology is embodied.*

- Yes, products/services developed mainly by a third party
- Yes, products/services developed together with a third party
- Yes, products/services developed mainly by my own firm
- No

2b. Innovated processes

Please, tick where appropriate
More than one answer possible

Between 1998-2000, did your firm bring production processes into use, which were technologically **improved** or **new** to your firm?

***Improved**: existing production processes, but with clearly higher performance, less costs or improves production reliability*

***New**: a process incomparable with previous processes of your firm and in which new technology is embodied.*

- Yes, processes developed mainly by a third party
- Yes, processes developed together with a third party
- Yes, processes developed mainly by my own firm
- No

2c. Innovative activities

Please, tick where appropriate

At the end of 2000, did your firm have unfinished innovation projects*

- Yes
- No

Between 1998-2000, did your firm have any technical innovation projects that were abandoned before completion?

- Yes
- No

* *Projects aimed at realising technologically new or strongly improved products, services and/or processes*

3a. Own research and/or development (R&D)

Please, tick or answer where appropriate

All in-house activities aimed at the development of technologically new or improved products, services or processes, including corresponding research and software development can be labelled as Research & Development (R&D)

Please, give an estimate of the R&D effort in your firm in 2000 in persons and man-years in South Africa.

Number of persons: …….
Expressed in man-years (1): …….

Please, give the innovation costs of your firm in 2000, incl. personnel costs and related investment expenditures (no depreciation).

R. ……..,000.-

This amount is:

- an exact figure
- a rough estimation

Our firm is:

- Engaged more or less continuously in R&D
- Engaged occasionally in R&D
- Not conducting any research and/or development

*(1) For example: 3 researchers or engineers work every week 20 hours on R&D is 3*20/40 = 1.5 man-years*

3b. Innovation expenditures 2000 *Please, tick or answer where appropriate*

Your firm is engaged in realising innovations by implementing new or significantly improved IT-applications or other technically-based knowledge. Please tick one ore more of the following innovation activities if applied by your firm in 2000. Subsequently, give an estimate of related expenditures.

Please, tick '**yes**' or '**no**' for each innovation activity:

Please tick 'yes' whenever innovation expenditures occurred, even if good financial data are not available. If good data are not available a rough estimate of expenditures is acceptable.

				If Yes: Please, give the innovation costs of your firm in 2000, incl. personnel costs and related investment expenditures (no depreciation).
Machinery/ Equipment	Purchase of advanced equipment or computer hardware specifically purchased for innovative purposes	Yes	No	R. ……..,000.-
Outsourced 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. Include costs of specialists that were temporarily employed by your firm to work on an innovation.	Yes	No	R. ……..,000.-
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)	Yes	No	R. ……..,000.-
Licenses/ Advises	Acquisition of patents, purchase of non-patented inventions and/or other expertise not mentioned before, e.g. in the field of software or information technology	Yes	No	R. ……..,000.-
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)	Yes	No	R. ……..,000.-
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	Yes	No	R. ……..,000.-

4a. Innovation and bottlenecks *Please, tick where appropriate*

In the last three years, did your firm experience bottlenecks as a result of which:

Our firm did **not innovate** at all.	Yes →	**Please, go to Question 4c**	
Our firm innovated, but:			
Innovation projects were not started?	Yes	No	**If you have ticked 3 times 'No', please go to Question 4b else go to Question 5**
Innovation projects were stopped prematurely?	Yes	No	
Innovation projects were seriously delayed?	Yes	No	

4b. Factors hampering innovation *Please, tick where appropriate*

If you ticked **at least one time Yes** in question 4a, please indicate the consequences for your innovation projects of the bottlenecks mentioned below		**No Bottle-neck**	**A bottleneck and as a result innovation projects were:**		
			Not Started	**Aban-doned**	**Seriously Delayed**
Economic risks	Cost-benefit analyses presented too many doubts				
Short of staff	Lack of qualified personnel				
Knowledge gap	Lack of information or familiarity with technologies				
Costs too high	Estimated costs too high or exceeding initial budget				
Short of finance	Lack of appropriate external finance sources				
Time to market	Could not meet required market introduction time				
Partnership	Co-operation 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				
Other bottlenecks	…….				

After you have answered Question 4b, please go to Question 5

4c. No technological innovative activities *Please, tick where appropriate*

According to your answer on **Question4a**., your firm was **not engaged** in innovative activities between 1998-2000. The main reasons for this are:			
Economic risks	Cost-benefit analyses presented too many uncertainties	Yes	No
Costs too high	Estimated innovation costs are too high for our firm	Yes	No
Short of staff	Lack of qualified personnel	Yes	No
No time	No time within the firm for innovative activities	Yes	No
Time to market	Could not meet required market introduction	Yes	No
Short of finance	Lack of appropriate external financial resources	Yes	No
Demand risks	Too many uncertainties on (future) product markets		
Other:	……..	Yes	No

5. Innovation in a broader sense *Please, tick where appropriate*

So far, all questions have dealt with technical product, process, or service innovation. This question refers to **all** of your firm's innovative activities, irrespective of the methods used. Between 1998 and 2000, which of the following activities your firm has undertaken?			
Business strategy	Reflect on, change of (long term) strategic goals of your firm	Yes	No
Marketing/design	Development of new marketing concepts and/or aesthetic change of product design	Yes	No
Reorganisation	Implementation of radical change of the organisation of your firm	Yes	No
Management	Implement new management tools, for example knowledge management	Yes	No
None of the above	None of the above activities were developed by the firm	Yes	

If you have indicated that your firm had no innovative activities at all→ Go to page 11

In all other cases → Go to Question 6

6. Product and/or service innovation and sales

Please, fill in the correct percentages and/or Tick where appropriate

For 2000, give an indication of the distribution of sales of products and/or services of your firm that:

	Distribution of Total Sales 2000
Did not change	…. %
Were technologically improved	…. % → ♦
Were technologically new	…. % → ♦
	100%

In 2000, did your firm sell products/services that were not only technologically new or improved to your firm, but **also** technologically new or improved to the **market**? *(i.e. your competitors did not introduce such product/services already)*

Yes → Share of *these* products/services in total sales 2000 was approximately: ……. %

No

Is the greater part of sales marked above with ♦ obtained with products/services introduced to the market after 1 July 2000?

Yes
No
Not applicable

7. Product and process innovation and your firm's market position

Please, tick where appropriate

Compared to the market leader in your firm's line of business, how have the innovations reported in questions 2a-2c affected *your* firm's relative market position? Between 1998 and 2000, our market position has:

Worsened substantially compared to the market leader
Worsened to a small extent compared to the market leader
No change compared to the market leader
Improved to a small extent compared to the market leader
Improved substantially compared to the market leader

Difficult to assess

8a. Innovation and the use of external information sources

Please, tick where appropriate

Between 1998 and 2000, which **external** information sources have been used for your firm's technological innovations (1)

		Source Not used	**Source used and was**		
			Of little Importance	**Important**	**Very Important**
Group	From mother or daughter company				
New personnel	From recently contracted personnel				
Buyers	Innovative ideas from buyers				
Suppliers	Innovative ideas from suppliers				
Competitors	Such as analyses of products/services of competitors				
Consultants	Ideas from private research institutes/consultancies				
Research labs	Ideas from public research institutes				
Universities	Including affiliated institutes				
Innovation Centres	Regional centres for innovation				
Sector institutes	Ideas from trade organisations				
Patents	Consult patents for innovative ideas				
Electronic info	Consult databases for innovative ideas				
Profession. literature	Consult literature for ideas				
Exhibitions	Including professional conferences				

(1) Projects aimed at achieving technologically new or strongly improved products, services or processes

8b. Innovation and the use of internal information sources

Please, tick where appropriate

Between 1998 and 2000, which **internal** information sources have been used for your firm's technological innovations (1)	**Source used and was**			
	Source Not used	**Of little Importance**	**Important**	**Very Important**
Purchase function				
Marketing and/or sales function				
Research function				
Development function				
Engineering function				
Production function				

9. Innovation in partnership: Partners in South Africa

Please, tick where appropriate

Innovation in partnership is working actively and together with other partners on the development of technologically new or strongly improved product, services, and processes. Most of the times, but not always, costs and revenues are shared in these partnership.
Please, do **not** include **outsourcing**.

Between 1998-2000, did your firm participate in such partnerships with organisations located in **South Africa**?

Yes
No → **Please, go to Question 10.**

If **Yes** Please, tick your partners and indicate on the right also where this partner is located.

Note *If there is more than one partner per row, please tick the location for your most important South African partner.*

Partner:		**Partner and located in South Africa in:**		
		Same Town/City	**Same Province**	**Other Provinces**
Own group	Within own enterprise group			
Buyers	Buyers/users of your products/services			
Suppliers	Suppliers of your firm			
Competitors	Firms active in your markets			
Consultants	Private research institutes/consultancies			
Research institutes	Public non-profit research institutes			
Universities	Including affiliated institutes			
Other partners	Namely:……..			

10. Objectives of innovation

Please, tick where appropriate

Between 1998-2000, what was the importance of the objectives mentioned below for the technological innovation projects of your firm?		**Not Important**	**Fairly Important**	**Important**	**Very Important**
Products/ market	Improving product or service quality, extend product or service range, open up new markets				
Labour	Reduce deployment or costs of labour				
Flexibility	Improve internal business process flexibility				
Materials	Reduce material consumptions				
Environment	Reduce environmental damage				
Regulations	Fulfilling regulations and standards				

(1) Projects aimed at achieving technologically new or strongly improved products, services or processes

11. Innovation in partnership: foreign partner *Please, tick where appropriate*

Innovation in partnership is working actively and together with other partners on the development of technologically new or strongly improved product, services, and processes. In this question, we focus on innovation **partners** your firm might have **located in countries outside South Africa**

Between 1998-2000, did your firm participate in such partnerships with organisations located in **foreign countries?**

Yes
No → **Please, go to Question 12.**

If **Yes** Please, tick your partners and indicate in which country this partner is located.

Note *If there is more than one partner per row, please tick the country for your most important foreign partner.*

Partner:		**Partner located in:**					
		SADC (1)	**Other African Countries**	**Europe**	**North America**	**South America**	**Asia/ Australia**
Own group	Within own enterprise group						
Buyers	Buyers/users of your products/services						
Suppliers	Suppliers of your firm						
Competitors	Firms active in your markets						
Consultants	Private research institutes/consultancies						
Research institutes	Public non-profit research institutes						
Universities	Including affiliated institutes						
Other partners	Namely:……..						

12. Innovation funds *Please, tick where appropriate*

Has your firm received a subsidy or other innovation funds in 2000 to develop technologically new or improved products, services, or processes?

Yes
No → **Please, go to Question 13a**

If Yes: Which of the following funds did your firm use for innovation in 2000?

Please, tick where appropriate
More than one answer possible

Technology and Human Resources for Industry Programme (THRIP)	Yes	No
Innovation Fund (DTI)	Yes	No
Support Programme for Industrial Innovation (DTI)	Yes	No
Sector Partnership Fund (DTI)	Yes	No
Competitive Fund (DTI)	Yes	No
Venture Capital (individuals, VC organisations)	Yes	No
Development Capital (Banks, IDC)	Yes	No
Research Cooperation (Scientific Councils)	Yes	No
Other, please name	Yes:…….	No

13a. Characteristics of product/service innovation *Please, tick where appropriate*

Product or service innovations refer to the development and introduction of new and/or improved products or services. Please, characterise these innovations of your firm.

Our product/service innovations are mainly:

Step by step changes of products/services
Drastic changes of products/services
Between 1998-2000, we did not have product/service innovations

13b. Characteristics of process innovation *Please, tick where appropriate*

Process innovations refer to the development and introduction of new and/or improved processes. Please, characterise the process innovations of your firm.

Our process innovations are mainly:

Step by step changes of processes
Drastic changes of processes
Between 1998-2000, we did not have process innovations

(1) SADC = Southern African Development Community, including Angola, Botswana, Democratic Republic of Congo, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, Swaziland, Tanzania, Zambia, and Zimbabwe. Exclude partnerns located in South Africa.

14a. Technology strategy	*Please, tick where appropriate*
Does your firm have a formal technology strategy?	Yes No
14b. Training in Technology and Innovation Management	*Please, tick where appropriate*
Between 1998 and 2000, did any of your employees attend (a) training course(s) in Technology and/or Innovation Management?	Yes No
14c. Person for Technology Management	*Please, tick where appropriate*
Is there a specific person in your firm who is responsible for the management of technology?	Yes No, **please go to Question 14d**
If **Yes**, indicate the management level of this person:	Senior management level Middle management level Junior management level

14d. Technology and innovation management tools			*Please, tick where appropriate* *More than one answer possible*
Between 1998-2000, which of the technology and innovation management instruments/tools mentioned below did your firm use to manage the innovation processes?			
Technology monitoring and scanning	Yes	No	
Technology forecasting and foresighting	Yes	No	
Competitive technological intelligence	Yes	No	
Competitor analysis	Yes	No	
Industry analysis	Yes	No	
Market analysis	Yes	No	
Technology and innovation audits of own organisation	Yes	No	
Core competence assessment of own organisation	Yes	No	
Intellectual property audit of own organisation	Yes	No	
Project portfolio management	Yes	No	
Cross functional teams in innovation projects	Yes	No	

15a. Internal consequences of product/service innovations					*Please, tick where appropriate*
Please indicate on a scale from 1 to 5, to what extent product/service innovations of your firm caused changes of other products, services or processes of your firm.	no changes 1	2	3	4	drastic changes 5

15b. Internal consequences of process innovations					*Please, tick where appropriate*
Please indicate on a scale from 1 to 5, to what extent process innovations of your firm caused changes of other products, services or processes of your firm.	no changes 1	2	3	4	drastic changes 5

16. Level of specialisation	
Which percentage of your firm's employees can be considered as highly trained specialists?	Percentage of specialists:……..
17. Level of education	*Please, give the correct percentage*
Which percentage of your firm's employees is educated on tertiary level?	Percentage of higher educated employees:……..
18. Organisational structure	*Please, give the correct number*
How many levels are there under the top management (chief executive) level?	Number of levels:……

THANK YOU VERY MUCH FOR COMPLETING THIS QUESTIONNAIRE
PLEASE GOTO PAGE 11

For returning the completed questionnaire, please use the enclosed stamped addressed envelope. A postage stamp is not required. In case you do not have this stamped addressed envelope anymore, return the completed questionnaire free of charge to:

Universiteit van Pretoria
University of Pretoria
Department of Engineering and Technology Management
Lynwood Road, Hatfield
0002 Pretoria

Filling out this questionnaire took you a lot of effort. As a token of our appreciation, we want to do something in return.
If requested, we can compare the economic and innovative performance of your firm with the other firms that participated in this research. With this information, you can get an impression of the relative economic performance of your firm.

Please indicate whether you want to use this possibility:

- ❑ Yes, we want to use this possibility. Our firm will be compared to other firms in the survey. Items included are sales, employment, export and innovative performance.

- ❑ No, we do not want to use this possibility

Maybe you feel the need to comment on this research in general or on this questionnaire in particular (maybe some questions were not clear to you or some questions were too difficult). In the box below, we saved some space for your comments. Please, feel free to comment!!

……

……

……

……

AGAIN, THANK YOU VERY MUCH FOR COMPLETING THIS QUESTIONNAIRE

W O R K I N G P A P E R S

Ecis working papers (April 2001):

98.1: Per Botolf Maurseth & Bart Verspagen:
Knowledge spillovers in Europe and its consequences for systems of innovation

98.2: Jan Fagerberg & Bart Verspagen:
Productivity, R&D spillovers and trade

98.3: Leon A.G. Oerlemans, Marius T.H. Meeus & Frans W.M. Boekema:
Learning, innovation and proximity

99.1: Marius T.H. Meeus, Leon A.G. Oerlemans & Jules J.J. van Dijck:
Regional systems of innovation from within

99.2: Marcel P. Timmer: Climbing the technology ladder too fast?:
An international comparison of productivity in South and East- Asian manufacturing, 1963-1993

99.3: Leon A.G. Oerlemans, Marius T.H. Meeus, Frans W.M. Boekema:
Innovation and space: theoretical perspectives

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