Does innovation lead to job creation?

a longitudinal study on innovative behaviour and its effect on employment in South African firms

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Master's thesis

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Date : June 8, 2005

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A longitudinal study on innovative behaviour and its effect on employment in South African firms

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Preface

In December 2003 I decided to go to Pretoria, South Africa, for a half of a year. Via the contact of Gerrit Rooks with the University of Pretoria (UP), I was invited by Professor T. Pretorius to do my final thesis on Innovation and Employment in South African industry. I thought it was the perfect way of concluding my years of studying Technology and Innovation Sciences at the TUe, the Netherlands. On July 7th 2004 I arrived in Pretoria, South Africa, the city where I would live for six months.

The subject of my research in South Africa was innovation and its effect on job creation. The research had to be carried out with an already existing dataset from the South African Innovation Survey (SAIS 2001) and a new to obtain dataset. Together with Ronnie van den Thillart and Bernard de Veer, I was responsible for the acquirement of the new dataset. The acquirement of the dataset was the main goal for my stay in Pretoria. With the facilities of the department of Engineering and Technology Management from the University of Pretoria we managed to obtain unique data. 97.7% of all the firms that participated with the SAIS 2001 participated again. With these complementing datasets, the impact of innovation on employment could be researched.

I consider my stay in South Africa a big success. For me, it was an experience of a lifetime to live for 6 months in the amazing country of South Africa. Beautiful scenery, the well-known wildlife, and an extreme amount of activities to expend left a lasting impression. It is a beautiful country but on the other side, confronting as well. Although prosperity is rising, poverty is still the order of the day. Millions of people live in slums, trying to find a way to live. It gave me a broader view on life.

My stay there was not only for personal enrichment, it resulted in a dataset, which enabled me to conduct exclusive longitudinal research. With this data unique knowledge about innovation and its effect on job creation in South African industry is obtained. To the best of my knowledge, it is the first time a research like this has been conducted in South Africa. The results are published in the report at hand.

Acknowledgements

I would like to thank the following people for their valuable contribution. They made it possible for me to conclude this report successfully:

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And of course my fellow students and friends Ronnie van den Thillart and Bernard de Veer. We worked closely together for our researches. We drew up the approach of

the data collection and spent many hours phoning hundreds of firms. We finished our reports with close cooperation. Without them this report would have never existed.

Eindhoven/Pretoria
May 2005

Rob Westerhuis

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Executive summary

South Africa is a country with a growing market and an abundant supply of natural resources. International trade has increased and the economic growth has been successive for the last decade. The GDP – per capita is relatively high compared to developing countries but the population below poverty line is around 50 percent. This indicates that the distribution of wealth is extremely uneven in South Africa. South Africa is presently a country with a two-layered economy. On the one hand it competes with developed countries, but on the other hand it has a very basic structure. For the above-mentioned reasons South Africa has the status of a developing country. The technological development of South African firms dependents upon foreign technologies and the national system of innovation is very low. This is concluded since firms in South Africa indicate to experience a lack of qualified personnel, have a low number of national innovative partnerships, have lack of (external) financial resources and experience restrictive governmental regulations. South African firms indicate that they experience negative effects on innovation projects due to a technology gap and indicated to have many R&D partnerships with foreign firms as well. Therefore South Africa can be determined as a technology colony.

Despite the economic growth, the unemployment rate is relatively high. According to official numbers the unemployment rate runs up to 31 percent where unofficial numbers state it is as high as 40 percent. The unemployment is seen as one of the most pressing socio-economic problems that face the South African government. A solution to the high unemployment can be found in innovation. This report examines what the effect of innovation is on job creation in the South African industry.

To assess the effects of innovation on job creation, distinction has to be made between product and process innovations. Both are believed to influence job creation in different ways. Product innovations that are successfully launched on the market will provide a bigger market share for the firm and results in firm growth. Besides increasing sales and revenues the employment demand will rise as well. Thus, innovation leads to job creation. But the innovative product can replace other products manufactured by other firms. This can lead to a decrease in market share for the non-innovative firm, including a decrease in employment demand. The jobs created in the innovative firm are at the expense of jobs in the non-innovative firm. Thus on sector level the effects of innovation on job creation are less rosy. Process innovation is often seen as a labour replacing innovation. Manual labour is replaced by machinery with job destruction as a result. However, process innovation can lead to lower production costs that on its return can lead to lower output prices. Lower output prices will increase the demand. A rise in demand will lead to increasing market share and firm growth. As stated above, firm growth leads to job creation but also to job destruction in other firms.

The effects of innovation on job creation in the South African industry are empirical examined with data from the South Africa Innovation Survey 2001 (SAIS 2001) and new obtained data (SAIS 2001 Revisited). The SAIS 2001 was conducted to acquire firm specific information and the innovative performance of South African firms over the years 1998-2000. This data is complemented with new data about employment from the year 2003. Under the name SAIS 2001 revisited the firms that cooperated with SAIS 2001 were asked to cooperate a second time. By means of a telephonic interview information about the employment figures in the year 2003 are obtained. From the firms that cooperated with SAIS 2001 97.7 percent cooperated with the SAIS 2001 revisited as well. With this unique dataset longitudinal research about innovation and the effects on job creation is examined. The analysis is done with the Two Stage Least Squares model after Multilevel Analysis. The dependant variable is employment growth in the period 2000-2003 and the independent variables are product and process innovations. Control variables are included in this analysis.

The effects of innovation on employment growth are ambiguous. Product innovation has a positive effect on employment growth in South African firms. Firms that had product innovation in the period 1998-2000 had bigger employment growth than firms that did not have product innovations. Process innovation on the other hand had a negative effect on employment. It seems that product innovations replace manual labour and this is not corrected by market mechanisms. Different control variables are taken into account and they have an impact on employment as well. The size of a firm is of influence on employment. The smaller firms indicate more employment growth than the larger firms. They seem to be the employment booster. The product innovations that were not only new to the firm but also new to the market were expected to have a bigger influence on employment growth than product innovations that were new to the firm only. One of the interesting findings according product innovations that were new to the market is that they have a negative effect on employment growth. The firms with these innovations show an employment decline. The latter two dummies concern foreign ownerships and if a firm started in the period 1998-2000. These dummy variables indicated that South African firms with foreign owners had an employment reduction there where starters in the period 1998-2000 had an employment growth.

1 Introduction

In this report the influence of technological innovation on employment in South African firms is examined. The reason for this research is explained in paragraph 1.1. The research question with accompanying sub-questions is given in paragraph 1.2. The latter paragraph will be used to explain the structure of this report.

1.1 Innovation and employment in South Africa

South Africa is a country with a growing market and an abundant supply of natural resources. The financial, legal, communication, energy, and transport sectors are well developed and there is a modern infrastructure supporting efficient distribution of goods to major urban centres throughout the region[1]. Although the national economic growth is successive for the past ten years, the unemployment rate is still very high. According to official numbers, the unemployment rate runs up to 31 percent[2] whereas unofficial numbers state it is as high as 40 percent[3]. The high rate of unemployment in South Africa is seen as one of the most pressing socio-political problems facing the government. A solution to this problem can be found in technological innovation. Innovation is one of the factors that influences employment.

Innovation and its causality to employment is an issue with a long historical background. Labour opposition to technological change go back at least as far as the industrial revolution, where resistance to major innovations was frequently publicized in the media. The 'Luddites', who derive their name from the non-existing mythical figure Ned Ludd, raised protests against new machinery (Dowrick and spencer, 1994; Pianta, 2003; Piva and Vivarelli, 2003; Verspagen, 2004). The Luddites deduced that new machinery was a replacement for manual labour, thus causing unemployment. Protests were raised and in 1811 the Luddites started sabotaging weaving machines and attacking steam loom factories. There was widespread public sympathy for the Luddites, but not within the industry. They had the army interfere at protests and had Luddites arrested. Several Luddites were hanged and many more were moved to Australia. The last Luddite demonstration in 1817 was put down with ease by the government[4]. Technological innovation as a means of power for the employer is what Karl Marx suggested in "das Kapital" (Marx, 1867). He stated that technology would begin to replace workers leading to an increase in unemployment. By this process, not only the labour demand decreases, but the capitalist would also use the high unemployment to cut down wages. The average labourer was at a disadvantage again.

In modern times, policymakers, authors, and social leaders are still concerned about job losses due to technological innovations. Conversely, economists plead that

[1] www.cia.gov
[2] http://www.statssa.gov.za/keyindicators/lfs.asp
[3] http://www.safrica.info/ess_info/sa_glance/demographics/
[4] www.learnhistory.org.uk/cpp/luddites.htm

innovation can destroy some jobs, but is also a driving force to create others. Numerous theories about the effect of innovation on employment have been published and discussed but empirical research is necessary to show the actual effects of innovation on employment. In European and American countries multiple researches among firms have been conducted to provide more insight on the effect of innovation and job creation. The European Union finances projects to improve the socio-economic knowledge of European firms. The report at hand is research on innovation and its effects on employment in South African firms. It is an empirical analysis, based on firm-level data from the South African Innovation Survey 2001, the SAIS 2001.

To map innovative performance of South African firms, a joint research project between the University of Pretoria and Eindhoven University of Technology developed the SAIS 2001. By means of a survey, specific information from 601 firms was obtained. These firms covered the manufacturing, service and wholesale sector. The data provides insight into innovative behaviour of South African firms over the period 1998-2000 and employment numbers in the year 2000. This data is complemented with new data collected throughout the year 2003. This data collection was done under the name "SAIS 2001 Revisited". The firms who participated in SAIS 2001 were interviewed again in SAIS 2001 Revisited. These complementing datasets provide unique longitudinal information, which is used to point out the influence of innovation on employment in South African firms.

1.2 Research question

In this report the effects of innovation on employment in South African firms will be empirically determined. The following question is the leitmotiv in this report:

- *How does innovation affect employment in South African firms?*

To find the answer for this question, different parameters have to be distinguished. Innovation is divided between product and process innovations. Product and process innovations seem to influence employment in different ways. Product and process innovations are categorized in radical and incremental innovations, along with imitations of existing products. This is called the degree of novelty. Each degree of novelty seems to have a different impact on employment. The size of a firm appears to be another important factor that influences employment. Therefore the following four sub-questions play an import role in this report:

- *How does product innovation affect employment in South African firms?*
- *How does process innovation affect employment in South African firms?*
- *How does the degree of novelty make a difference in job creation?*
- *Do SMEs contribute more to job creation than large enterprises?*

The effects of innovation on employment will be explored on firm and sector levels. It is assumed that the effects on the firm level will be stronger than the effects on the

sector level. A distinction is made between firms in the manufacturing and service sectors.

1.3 Structure of the report

This report consists of nine chapters. Chapter 2 will give a theoretical and empirical background about the innovation and employment topic. The theories and empirical research that are described in this chapter will provide the basis of the hypotheses that will be tested. In chapter 3 the economic, technological, and innovative status of South Africa is described. This is done after the history of South Africa is briefly considered in order to describe the origin of South Africa's present-day economy. In chapter 4 the method of research is described. The chapter elaborates on the data that was available and how the new data was collected. The survey method is specified precisely and the validity of the data is assessed. After the main characteristics of South African firms are described in chapter 5, the statistical method and the empirical analysis are explained in chapter 6. The last two chapters are reserved for the conclusion and discussion.

2 Theoretical background

This chapter will elaborate on the literature about innovation and its causality to employment. The definition of innovation is given in paragraph 2.1. Following the definition, it is discussed how innovation can have an impact on employment as well. Paragraph 2.2 will expand on the side effects of innovation and in paragraph 2.3 the degree of novelty of the innovation is subdivided. In paragraph 2.4 the influence of firm size on innovation and employment is discussed and paragraph 2.5 is used to show a difference in firm and sector level. In the latter paragraph a résumé of the literature is given in a graph and the hypotheses are formulated.

2.1 Innovation and its effect on employment

Innovation is conventionally defined in terms of the introduction of something new or different, and/or the introduction of new things or methods. Schumpeter, one of the most famous economists of the 20th century, separated innovation in product and process innovation. He defined product innovation as "the introduction of a new good (...) or a new quality of good" and process innovation as "the introduction of a new method of production (...) or a new way of handling a commodity commercially" (Pianta, 2003 pag 4). Innovation is seen as the driving force behind the competitiveness of firms and plays an increasingly important role in prosperity and growth. Innovation is a mechanism through which technology can be leveraged to create wealth and contribute to a better life (Freeman, 1982). Porter stated that "Firms create competitive advantage by perceiving or discovering new and better ways to compete in an industry and bringing them to market, which is ultimately an act of innovation" (Porter 1990, p.45). Competitive advantage has a repercussion on the growth of the firm, including the sales, revenues, and *employment*. Innovation can create and obliterate employment. According to Alonso-Borrego (2001) innovation is one of the main sources of employment dynamics. When talking about the effects of innovation on employment, first a distinction has to be made between product/service and process innovations. Both are believed to have an impact on employment, but in different ways. Two leading ideas explain why this difference has to be made.

Product/service innovation, from here on out shortened to product innovation, is believed to influence job creation in a positive way. Product innovations will lead to improved or new products. The improved or new products are expected to lead to an increase of demand or a creation of a new market. The innovator creates a competitive advantage and will increase his output. The product innovation leads to economic growth, with increasing employment demand as a result. This is a positive effect on job creation and is called the "Welfare effect" (Katsoulacos, 1984).

Process innovation on the other hand, is often associated with job destruction. Manual labour can be substituted by machinery and automation. Job destruction will be the result of this innovation. Hence, process innovation has a negative effect on

job creation. The ideas mentioned above have many side effects that will be discussed in paragraph 2.1.1 and 2.1.2.

From the SAIS 2001, information about innovation in South African firms is known. The cooperating firms indicated if they had introduced product or process innovation in the period 1998-2000 and they also disclosed the number of employees in their firm the year 2000. With the data from SAIS 2001 revisited, the number of employees in the same firms is known in the year 2003. With these numbers the employment growth can be determined. The employment growth is indicated as the percentage of employment change according to the year 2000. This percentage is measured with the following formula:

$$emp.gr. = \frac{emp.2003 - emp.2000}{emp.2000}$$

The number of employees in the year 2003 reduced by the number of employees in the year 2000 gives the absolute number of change in employment. The absolute number of employment change divided by the employment number of the year 2000 gives the percentage of employment change. With this data the result of innovation over the period 1998-2000 is tested with employment growth in the period 2000-2003.

As stated above, the effects of innovation over the period 1998-2000 are tested with employment growth in the period 2000-2003. This is in concordance with what Diederen, van Meijl and Wolters (2002) concluded. They stated that the process of adoption and diffusion of an innovation differs for every innovation but this takes time to develop. According to Diederen et al. (2002) this process takes at least one to two years. Therefore the three year time span in this research can be stated as a good measurement.

2.1.1 Product innovation

The effect of product innovation on employment is likely to be favourable. Various studies show that product innovation has a positive impact on employment growth on firm level. An innovative firm that launches a new product successfully to the market enhances its labour needs (Katoulacos, 1984; Vivarelli, Evangelista and Pianta, 1996; Peters, 2004). A successful new launched product will provide new or bigger market share for a firm. The sales will increase and the firm will be able to expand. As a result of this growth the employment demand will rise. Via this mechanism, innovation leads to job creation. Job creation is called the "compensation effect". However, both negative and positive side effects (externalities) on job creation due to product innovation are present. These are discussed in paragraph 2.2.

2.1.2 Process innovation

Process innovation is often a 'labour saving' innovation. Machinery and automation can be deployed to replace manpower. Fleck (1984) predicted a loss of 1.4 jobs per robot introduced in an "average plant". Normally the short-run effects of process-innovation are negative on employment, when manual labour is replaced by machinery or automation. Job destruction is called the "displacement effect". Via market mechanisms, process innovation can be a driver of employment growth as well.

Process innovation can increase a firm's productivity, which will make a firm capable of producing the same amount of output with less input, resulting in cost reduction. A firm can shift this cost reduction to lower output prices (Peters, 2004). To what extent cost reduction will lead to lower prices depends on the competition in the market (IEEF, 2004). The higher the intensity of competition in the market, the more cost reduction will lead to reduced output prices (Case, Fair, Gärtner and Heather, 1999). Reduced output prices will increase the demand, with firm growth and labour demand as a result. Besides competition, price elasticity determines to what extent cost reduction will lead to lower prices. The price elasticity is an indicator of the influence of the price of a product on the demand of that product. High price elasticity indicates a strong relationship between price and demand. Papanikos (2004) asserts that process innovation does not only lead to increasing employment demand via cost reduction. He also states that more workers are needed for the application of new production processes and to handle the required paperwork.

Pianta (2003) stated that the most innovative firms introduce process and product innovations simultaneously (Pianta, 2003). A product needs a process to generate the creation. With the introduction of a new product, a new process may be necessary to be able to produce this new product.

2.2 External effects of innovation

An innovator who increases his market share can take away market share from a non-innovator. According to Katsoulacos (1986) new goods can be replacements for old goods. This implies that the innovative firm takes his increasing market-share from a non-innovator. The innovator creates jobs, but the non-innovator loses jobs. Thus innovation can create jobs, but also destroy some others. This mechanism will reduce the overall expansion in labour demand on industry (sector) level. According to Piva and Vivarelli (2003) and Verspagen, (2004) the relocation of jobs can be termed the 'business stealing effect' and is often acknowledged as the main reason why results at firm level cannot be considered as representative for the overall employment effects of innovation. How overall employment is changed depends on the balance between job-creation and job destruction (Katsoulacos 1984, Vivarelli et al., 1996). The sum of employment creation plus destruction is identified as 'job reallocation' (Audretsch, 2002; Alonso-Borrego, 2001).

The effects of innovation on employment can effect the suppliers of the innovative firm. The input demand of the innovative firm will rise and therefore the output of the supplier as well. The supplier will undergo firm expansion, and its labour demand will increase. This is a positive externality of innovation on employment. Another externality depends on complementarities between products. A complementary arises when the increasing demand for an innovative product raises the demand for a required accompanying product. Example: With the introduction of cell phones a new market for ring tones came into being. The market of accompanying products will grow with its consequences on job creation. These effects are mainly intersectorial. A supplier from a product can be active in another sector than where the innovation was done. This counts additionally for complementary products.

Competitors of the innovative firm who are not able to catch up with the technological progress, will lose market shares or eventually disappear. Employment destruction will be a result. This is already stated as a negative externality in the beginning of this paragraph. Hence, when examining the impact of innovation on overall job creation, it's important to show a difference between firm level and sector level. Paragraph 3.5 elaborates on the difference in firm and sector level.

2.3 Degree of novelty

Innovations can be classified. Some innovations have a more drastic impact than others. The more an innovation distinguishes itself from other products, the more drastic an innovation is. If a drastic innovation satisfies the new market demand more than the older products, there will be a large impact on the market share of the firm. In this report innovations are segregated into radical and incremental innovations or imitations of existing products. Each is expected to have a different impact on employment growth.

2.3.1 Radical, incremental and imitation

When a firm is the first to market a new product or introduces a new process, the innovation is called an invention. An invention is a radical innovation. When followers in the same industry, including other countries, adopt this idea it is called imitation. Imitations of existing products can come accompanied with incremental improvements or adaptations to new users' needs. Pianta (2003) distinguished between changes in products (or services) as radical innovations (inventions), incremental improvements on previous ones or imitation of goods already produced in other firms. It is assumed that an incremental innovation or imitation has smaller impact on the market than a radical innovation and thus less influence on the creation of employment. Bandury and Mitchell (1995) described incremental innovations as "refinements and established designs that results in substantial price or functional benefits to users". They examined the market share and business performance of 86 firms in the pacemaker industry. The researchers found a positive relation between incremental product innovations and their market share, thus

equaling employment growth. Firms that adopted existing products only noticed a small positive relationship in their market position.

Brouwer and Kleinknecht could not find employments effects in enterprises pursuing an imitation. Peters (2004) conversely found a positive relation between imitators and job creation. In this research innovation is divided into "innovations new to the firm" and "innovations new to the market". This division is called the degree of novelty.

2.4 Firm size

Firm size seems to be an important factor in innovative behaviour (Pavitt, 1984; Acs and Audretsch, 1988; Julien, 1993). Many researches are conducted to describe the effect of firm size on innovation. Prior researches about the size of a firm and its innovative output conclude that small and medium sized enterprises (SMEs) exceed that of larger firms (a SME is defined as a firm with fewer than 500 employees). This is concluded in spite of the fact that larger companies have more financial and personnel resources, they can apply economies of scale in research, have greater bargaining power with suppliers, and have superior networking information. SMEs owe their ascendancy to the ability to react more quickly to changing business environments, having greater internal flexibility, they are more willing to take risks, they are more efficient, and have informal communication coupled with less bureaucracy (Bommer and Jalajas, 2004). These advantages make the SMEs more innovative than large firms and explain why SMEs are stated as employment boosters.

Audretsch (2002) found in his empirical study among Small and Medium Enterprises (SMEs) the dynamic role of SMEs in the United States economy. He concludes that small firms place an efficiency burden on the economy. Viewed on a static scale, a small number of firms producing on a smaller scale exceed higher production costs, which is where the consumer suffers the adverse consequences of it. But throughout the long run, SMEs are important sources for innovation and employment growth. This line of thought had a big influence on public policy in Canada, where policies stimulated SME expansion (Picot, Baldwin and Dupuy, 1994). However, a research conducted over a period of 14 years in Canadian firms showed a different result. It was found that employment growth in small and large firms were quite similar. Heunks (1998) explored the role of innovation in SMEs, in the relation to a firm's success. He found no evidence of SMEs having more innovations than large firms. Actually, he found that most kinds of innovation tend to occur more often in larger firms. It can be stated that the size of a firm can have an impact on employment because of the different innovative tendency. There is also a direct impact of firm size on employment. This has to be taken into account when examining the influence of firm size on employment.

2.5 Firm and sector level

The impact of innovation on employment at firm level differs from the impact seen at sector level. The innovations are done in the firms and it is here where it has its first effect on employment. The impact that innovation has on the level of firms is expected to be positive. The innovative firms grow faster and are supposed to create employment, which is known as the compensation effect. This employment creation can be at the expense of employment in non-innovative firms, where job destruction could occur (displacement effect). A growing amount of literature has explored the impact of innovation on employment at firm level and at sector level. In Table 2.1, outcomes of researches on innovation and job creation relations on the firm level are exposed (Pianta, 2003).

Study	Countries	Years	Level of analysis	Innovation data sources	Results on employment
Firm level studies					
Entorf and Pohlmeier, 1990	Germany	1984	Cross firm, manuf.	Group of German firms	Positive with product innovation
Machin and Wadhwani, 1991	UK	1984	Cross firm, manuf.	British workplace industrial relations survey	Positive
Blanchflower, Millward and Oswald, 1991	UK	1984	Cross firm, manuf.	British workplace industrial relations survey	Positive
Brouwer, Kleinknecht and Reijnen, 1993	Netherlands	1983-1988	Cross firm, manuf.	Dutch survey	Negative Positive with product innovation
Meghir, Ryan and Van Reenen, 1996	UK	1976-1982	Panel of firms, manuf.	SPRU innovation database and patents	Positive more flexibility
Klette and Forre, 1998	Norway	1982-1992	Panel of manuf. firms	Norway universe of manuf.	Negative
Van Reenen, 1997	UK	1976-1982	Panel of manuf. firms	Survey on UK firms	Positive
Smolny, 1998	Germany	1980-92	Panel of manuf. firms	Survey on German firms	Positive
Greenan and Guellec, 2000	France	1986-1990	Cross firm, manuf. Cross sector	Innovation survey	Positive at the firm level Negative at the industry level for process innovations

Table 2.1 Effects of Innovation on the quantity of employment; Selected empirical studies on firm level (Source: Pianta, 2003)

It seems that innovation has a positive effect on employment on the firm level. Two exceptions have been publicized by Klette and Forre (1998) and Brouwer, Kleinknecht and Reijnen (1993). On the industry level it seems that innovation has a less optimistic influence on employment, according to the different researches shown in Table 2.2 (Pianta, 2003). This could be accounted for the business stealing effect.

Industry level studies					
Meyer Kramer, 1992	Germany	1980s	Input output model all economy		Negative, differentiated by sector
Pianta, Evangelista and Perani, 1996	G6 countries	1980-1992	Cross sector 36 manuf. industries	R&D and patents	Differentiated by country
Vivarelli, Evangelista and Pianta, 1996	Italy	1985	Cross sector 30 manuf. industries	Innovation survey	Negative of process innovation Positive of product innovation
Pianta, 2000, 2001	5 EU countries	1989-1993	Cross sector 21 manuf. industries	Innovation survey	Overall negative Positive of product innovation
Antonucci and Pianta, 2002	8 EU countries	1994-1999	Cross sector 10 manuf. industries	Innovation survey	Overall negative Positive of product innovation
Evangelista and Savona, 2002, 2003	Italy	1993-1995	Cross sector service industries	Innovation survey	Overall negative, differentiated by service industries and size

Table 2.2 Effects of Innovation on the quantity of employment; Selected empirical studies on sector level (Source: Pianta, 2003)

In February 2005 the European research project Innovation and Employment in European Firms, IEEF, published an impression of the effects of innovation on employment. 19,000 firms, from both the manufacturing and service sector, from 4 European countries participated in this research. The main results reveal that process innovation in the manufacturing sector tends to displace employment, but compensation effects are present. It appears that these effects neutralize each other. Product innovation shows no displacement effects and is associated with employment growth, even when the destruction of old products is taken into consideration. In the service sector the same results are found, though they are of less important influence (Harrison, Jaumandreu, Mairesse and Peters, 2005). In following table a résumé of the different expected effects of innovation on employment is given. In the table innovation is distinguished between product and process and the effects are separated on firm and sector level.

<table>
<tr><th></th><th>Firm level</th><th>Sector level</th></tr>
<tr><td rowspan="2">Product Innovation</td><td rowspan="2">- Increasing Market Share, firm growth, increasing employment demand

Job creation</td><td>- Job creation by innovators, job destruction by non-innovators:
"Business Stealing effect"

Job destruction</td></tr>
<tr><td>New markets, firm growth, increasing employment demand

Job creation</td></tr>
<tr><td rowspan="2">Process innovation</td><td>- Automation as labour replacement

Job destruction</td><td>- Job creation by innovators, job destruction by non-innovators:
"Business Stealing effect"

Job destruction</td></tr>
<tr><td>- Lower production costs, lower prices, increasing sales, firm growth, increasing employment demand

- Application of new production processes and more required administration

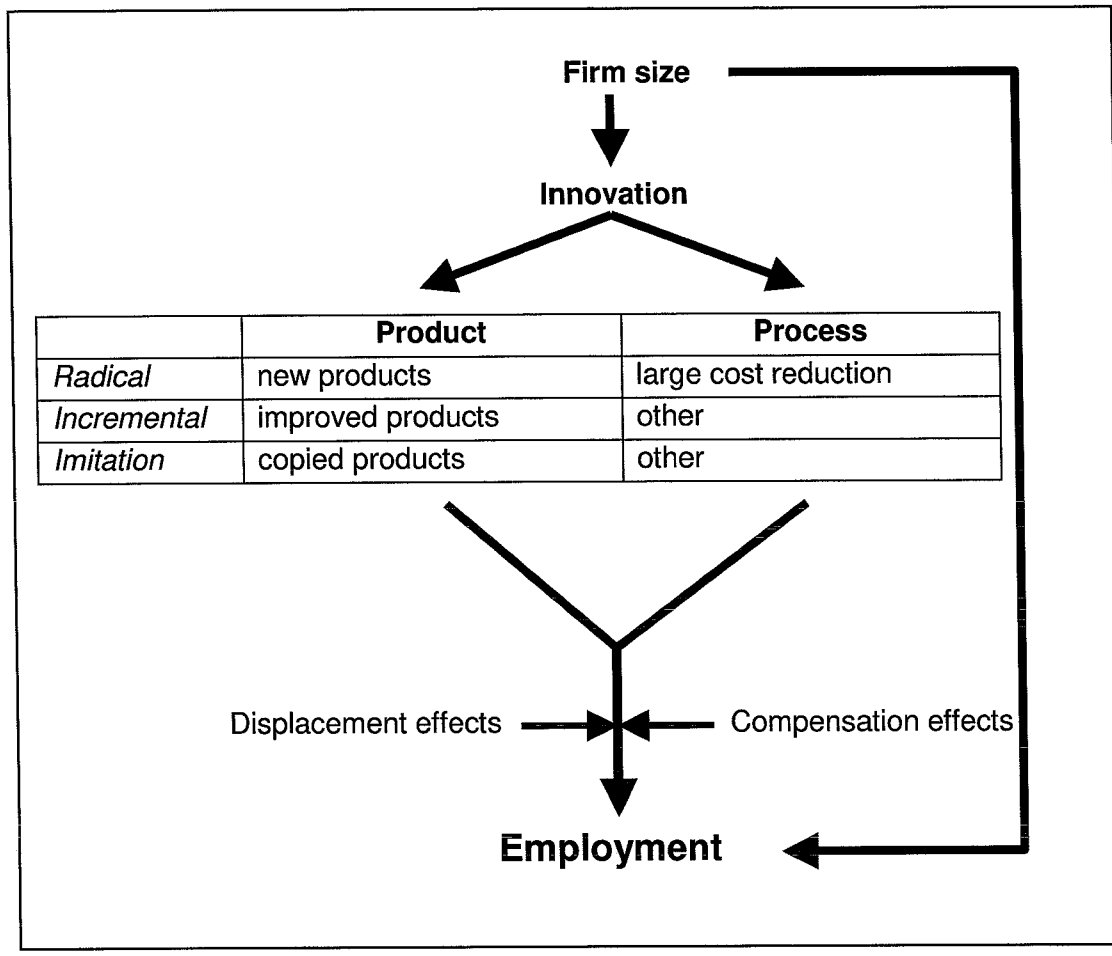
Job creation</td><td>- Increasing market, firm growth, increasing employment demand

Job Creation</td></tr>
</table>

Figure 2.1 Effects of product and process innovation on firm and sector level

2.6 Innovation in South Africa

The following figure graphically represents the influence of innovation on employment. It is a résumé of former paragraphs in a diagram form.



	Product	Process
Radical	new products	large cost reduction
Incremental	improved products	other
Imitation	copied products	other

Figure 2.2 Graphical display of the effect of innovation on employment

Innovation can affect employment. The different effects of product and process innovation on employment will be empirically examined in this report. Via displacement and compensation effects, employment can be destroyed or created. In this research the effects of innovation on employment are on firm level. In the analysis the effects of innovation on sector level are researched as well. According to former researches on this topic, it is assumed that product innovation has a positive effect on job creation on firm level. This counts for the manufacturing sector as well as for the service sector. There is no reason to believe that this would not be the case in South Africa. Therefore the first hypothesis is:

> *Hypothesis 1: Firms that introduce product innovations create more jobs than firms that do not introduce product innovations.*

Process innovation is often acknowledged as a labour saving innovation. It is seen as a mechanism to replace manpower. But via market mechanisms, process innovation can also lead to job creation. Cost reduction due to process innovation can lead, via price-elasticity and competition in the market, to lower market prices what can lead to employment growth. Which way the balance between destruction and creation will tilt is unclear. Therefore the hypothesis is:

Hypothesis 2: Process innovation does not change the employment demand.

In chapter 2 is descried that South Africa is mainly "imitating" instead of inventing new products and processes. If these imitated products are already on the South African market, the impact on employment is less for the imitating firm. If the imitated products are not on the South African, market the product has the same impact on employment as an invention.

Hypothesis 3: An innovation new to the market has a larger influence on job creation than an innovation only new to the firm.

SME's appear to be a source of innovation. It seems that SME's exceed the innovative output of that of large firms. Therefore following hypothesis is formulated:

Hypothesis 4: SME's contribute more to employment growth than large enterprises.

The expectation is that the effects of innovation on firm level influence each other. The jobs created in a firm can have jobs destroyed in other firms as a consequence. Innovation and its effect on firms has to be examined on sector level as well. Therefore the hypotheses are tested with these effects taken into account. With the statistical method as explained in chapter six these hypotheses are tested.

3 South Africa

In this chapter the economic, technological and innovative status of South Africa is presented. A brief summary of the history of South Africa is given in paragraph 3.1. The history in paragraph 3.2 will provide some background information about the factors that constitute the economic climate in South Africa today. Paragraph 3.3 will provide the regional, sectorial and size distributions of South African firms. This chapter has been written by Ronnie van de Thillart, Bernard de Veer and Robbert Westerhuis

3.1 History of South Africa

Modern humans have lived in South Africa for 100.000 years. However, even before that time the earliest ancestors of humans have lived in South Africa. Since the year 1939 the earliest known remains of the ancestors of modern man (Hominids) have been discovered in an area known as "the cradle of humankind". It is located near Johannesburg. Remains dating back from between 1.5 to 3.5 million years old, have been found there.

The earliest inhabitants of South Africa, at least the earliest that we can name, were the San people (also known as Bushman or Xhosa) and a racial grouping called Khoekhoe people (also known as Hottentots or Khoikhoi). Both were residents of the southernmost tip of the African continent. Evidence of their existence is still visible today. Bushmen paintings can be found in many locations all over South Africa. The Khoikhoi mainly lived around southern and western coastal strips. This area was a good grazing area for their cattle.

These people were also the first to meet the European settlers (Ross and Cuijlburg, 2001). With the arrival of the first European settlers the written history of South Africa commences. The first European to set foot on South African soil was Jan van Riebeeck, who anchored in Table Bay, at the foot of the Table Mountain, on the 6th of April 1652. The Dutch realized the strategic and economic importance of the Cape for the Dutch-East India Trading Company. Van Riebeeck accompanied by eighty two men and eight women, had been instructed to establish a strong base to provide the companies ships with fresh supplies on the long journey from Europe to Asia. The settlement started to flourish and the need for labour and agricultural land grew continuously. Some of the white farmers, wanted to expand their territory by moving inland. They were referred to as Trekkers or Trekboere. This did not occur without a struggle. Several armed conflicts with the native inhabitants, the Khoikhoi and the Xhosa, occurred as a result of their decision. In 1835 "Die Groot Trek" started, when more than 10,000 Boers, the "Voortrekkers" left for the north because of economic problems and the threatening danger of conflict with the Xhosa. They were also discontent with the English colonial authorities that annexed South Africa in 1806 from the Dutch. The Voortrekkers were dissatisfied because the English colonial authorities didn't provide sufficient protection, had forbidden the slave trade and

postulated the equality of whites and non-whites. This Groot Trek led to several collisions with Zulus, who eventually were completely defeated in the famous "Battle of Blood River" in 1838. The foundation of the first Boer Republic in Natal was a fact, but only for a short period. In 1842 British troops occupied Natal and annexed it as a crown colony. The Voortrekkers then moved even further northwards. The colony developed into a modern state and the whites tended more and more towards a policy of land annexation and suppression of the black population. A modern "democratic" state was formed when the British colony and the Boer Republics were united and which formed the South Africa Union.

According to the Native-Land Law, 13 percent of the land in South Africa was declared reservations for blacks. Only whites had the right to vote and no black person was allowed to purchase land from the 87 percent of the territory of the union, and vice versa. These were the beginnings of "Apartheid"

In 1910 racial separation was introduced by way of legislation. These laws diminished the rights of the black majority. Black workers were limited to only subordinate work to secure the better positions for the white population. Although the majority of the population was black, they only possessed thirteen percent of the land in South Africa, and they were excluded from buying land outside reservation areas. They had no right to vote or to strike and they had no political influence. Dispossessed and having no voice in matters resulted in the formation of several liberation movements. Among them was the African National Congress (ANC).

The National Party – a white congress – was able to suppress any resistance with little effort for many years. The conflicts got worse, however, after the Second World War and the whites became nervous. This led to a huge election victory of the right-wing National Party (NP) in 1948. Dr. D. F. Malan, the leader of the NP, upheld apartheid-policies. Interracial relations were forbidden, and racial segregation was prohibited. Different races were disalowed to use the same public amenities, such as drinking fountains, restrooms and public transport. Bantu education was introduced, which was of a poor standard and kepte black children at a disadvantage. Apartheid would only end fifty years later.

It is clear that South Africa is a country with a unique history. Its inhabitants are an interesting composition of Western, African and many other cultures. This uniqueness is evident from the fact that South Africa is the only country that has eleven official languages.

In 2005 apartheid has been gone for eleven years and the country is now reinventing itself. It is slowly emerging from its isolation and the lifting of all trade barriers, has opened South Africa to the rest of the world. In recent years many black empowerment regulations have been passed, obligating firms to acquire personnel that represent the different cultural backgrounds. According to the Act, "broad-based black economic empowerment" – with an emphasis on 'broad-based' - refers to the economic empowerment of all black people including women, workers, youth, people

with disabilities and people living in rural areas5. This will change the profile of working population of South Africa completely. These developments and the more recent political shifts have had a major impact on the industry in the past and will continue to do so in the future - making the entire industry unique to the world.

3.2 South Africa today

South Africa is presently a country with a two-layered economy. On the one hand it competes with developed countries, but on the other hand it has a very basic structure. South Africa has lower resources per capita than developed countries and shortages/inadequacies in its socio-economic infrastructure[6]. It is therefore regarded as a developing country. In paragraph 3.2.1 the economic characteristics of South Africa will be compared to some other developed and developing countries. In paragraph 3.2.2 and 3.2.3 respectively, the technological and innovative status will be discussed.

3.2.1 Economic status

In this paragraph some important indicators of the state of the South African economy like GDP, Inflation and Unemployment rates are benchmarked against the same factors in some other developed or developing countries. This will give a comparison of the economic status of South Africa against other countries at present.

Economic indicators

In the table 2.1 the economic characteristics of several countries are summarised. Included are some of the largest economies of Europe and North America and some of the leading innovative countries in Europe, like Sweden and the Netherlands. Also Mozambique is included, another African country.

[5] http://www.southafrica.info

[6] http://www.agrement.co.za/export%20of%20build.html

	South Africa	Netherlands	European Union	US	Mozambique	Ireland	Sweden	France	Germany
GDP (billion $)	456.7	461.4	11.05 trillion (2004)	10.99 trillion	21.23	116.2	238.3	1.661 trillion	2.271 trillion
Inhabitants (million)	42.8	16.2	457 (2005)	290,3	17.2	3,9	8,9	60.2	82.4
GDP – per capita ($)	10,700	28,600	25,700	37,800	1200	29,600	26,800	27,600	27,600
Unemployment	31	5.3	9.1	6	21 (1997)	4.7	4.9	9.7	10.5
Population below poverty line	50%	N/A	N/A	12%	70% (2001)	10% (1997)	N/A	6.5% (2000)	N/A
Inflation (%)	5.9	2.1	2	2.3	14	3.5	1.9	2.1	1.1
Exports (billion $)	36.77	253.2	850.3 (2002)	714.5	0.7	98.31	102.8	346.5	696.9

Table 3.1 Economic characteristics of the year 2003 (source: CIA-factbook 2004[7])

South Africa cannot be considered a big economic power. The GDP (Gross Domestic Product) of South Africa shows results comparable to the Netherlands. The human resources situation, however, between the two countries, are completely different. The Netherlands has 16 Million inhabitants and South Africa 44.8 Million. This means that GDP per capita shows a different result. GDP per capita is low compared to developed countries. However GDP per capita is significantly higher in South Africa than in most other African countries.

Although GDP per capita is relatively high, at least when compared to other African countries, the population below the poverty line is high (50%). This indicates that the distribution of wealth is extremely uneven in South Africa.

Unemployment and inflation are high - even compared to other African countries. The actual unemployment rates are believed to be even higher that the official percentage of 31%, and will be closer to forty than to thirty percent. In recent years there has been a dramatic increase in unemployment: the rate has moved up from 29 percent in 1999, to 40 percent in 2004[8].

Only 8.05% of the GDP in South Africa involves exports. This is low compared to developed countries that have export ratios extending beyond 50%. Low export ratios are expected in developing countries, however, when comparing export growth in South Africa to other countries, it has grown less rapidly. Between 1992 and 2002 global exports of all sectors increased by 4.93% per year. However, the exports of all sectors for developing countries rose considerably faster and the figure is 10.54% per year according to Kaplan (2004).

[7] http://www.odci.gov/cia/publications/factbook

[8] Afrol news source: http://www.afrol.com/articles/12037

The export growth of South Africa was only 4.44% in the period between 1992 and 2002. Export growth is more prominent in developing countries than in developed countries. South Africa's performance in terms of exports has been particularly weak (Kaplan, 2004).

South Africa has to face different challenges because of the increase in competitiveness in global exports from other developing countries (China in particular), and because of an important change of exports composition from low to middle/high technology. To overcome these problems South Africa has to increase its exports, and more importantly, South Africa has to increase the technological complexity of its exports. Looking at the figures of the last decade it is clear that South Africa's performance has been weak compared to the rest of the world and other developing and middle-income countries in particular.

3.2.2 Technological status

The technological status of South Africa is discussed in this paragraph. Two different indicators will be used. These indicators are the "Backwards Integration Model" and the "Technology Gap".

The Backwards Integration Model

Buys (2004) used a model called the Backwards Integration Model (BIM) to assess the stage of technological development of South Africa. This model classifies five different stages of technology development as shown in see table 2.2.

Stage I:	Local distribution, marketing, sales and after-sales services of foreign products and services.
Stage II:	Local production and manufacturing of products and services using foreign process technology.
Stage III:	Local improvement of products and processes using foreign technology.
Stage IV:	Local development of new products and processes using foreign technology
Stage V:	Local technology development

Table 3.2 Backwards Integration Model (BIM) (source: Buys, 2004)

South African firms are mainly active in stage III of this model (Buys, 2004). This means that most firms in the South African industry are involved in the *improvement* of products and processes using foreign technology. De Wet calls countries that are dependent upon foreign technologies "technology colonies" (De Wet, 2001). Buys therefore states that, "South Africa is a type of technology colony whose industries are dependent upon foreign technology for the improvement of its products and processes" (Buys, 2004).

According to Alali perpetual dependency upon foreign technology can lead to a failure in developing one's own local capabilities (Alali, 1995). The 'follower' status of South Africa has even more disadvantages. Leaders set the standards, have access to monopoly power and they establish the brand names (Buys, 2004). But on the other hand is stated that in many circumstances the followers are more successful than the leaders (Christensen and Roosenbloom, 1995), on firm level as well as on national level. Many developing countries have been more successful in their follower status than the leaders and are caching up using foreign technology (Kim, 1997). Oerlemans states that the current status as follower has a positive effect on South Africa as a whole (Oerlemans, Pretorius, Buys and Rooks, 2003), however, it is unknown if this follower status is sustainable in the future. The low number of export ($36.7 billion) to other countries from South Africa (30% of firms have export ratios above 10%), could be an indicator of the negative consequences the follower status already has on the economy. Another indicator is the fact that only 12% of firms transfer or sell technology (Oerlemans et al., 2003).

The technology gap

The difference in technological development between two countries is indicated by the technology gap. In literature the technology gap is determined by measuring the rate of imitation relative to rate of innovation between countries (Glass and Saggi, 1998). The size of the technology gap determines the ability that developing countries have to absorb different types of technology from developed countries. A large technology gap limits the ability to adopt foreign technologies.

This problem originates from differences in characteristics between the two countries. In countries where capital (i.e. knowledge, buildings, machines, etc.) is relatively easy to obtain and where labour is expensive, one typically finds that production will be more capital intensive. Countries where capital is scarce and labour relatively cheap will produce products more labour intensively. Technology development is influenced by these circumstances (Katz, 1987).

Besides the difference in capital-labour ratio, the market in developing countries differs from the market in developed countries. The size of the local market is considerable smaller than that of their counterparts in developed countries. A market in a developing country is usually not more than one to ten percent of the size of a developed country. A distinction in market size induces differences in plant size and technology.

South African firms have been severely impacted by this technology gap, because it has created bottlenecks that hamper innovative projects. Between 1998 and 2000, 5.2% of innovative manufacturing firms indicated that projects were not started due to the knowledge gap (Rooks and Oerlemans, 2005). In Figure 3.1 it becomes clear that this percentage, in most cases, is double that of European countries. This data was retrieved from the comparable CIS (Europe) and the SAIS (South Africa) databases.

Another finding was that not only were many projects not even started due to the knowledge gap, the projects that were started, experienced delays as a result of the technology gap. 16.9% of South African firms indicated that innovation projects were seriously delayed due to the technology gap (Rooks et al., 2005). This is higher than most European counties, with the exception of Finland.

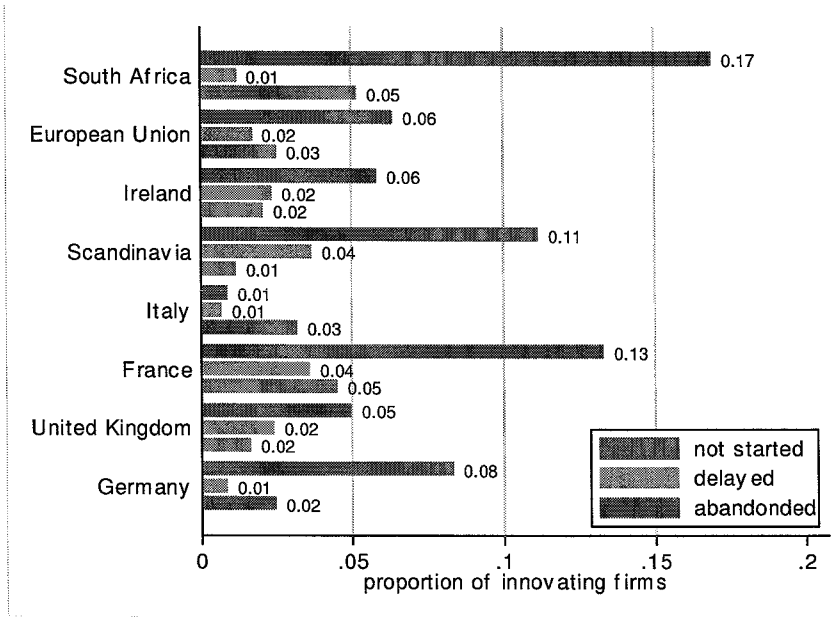


Figure 3.1 Delays or innovations not started at all due to the knowledge gap (source: Rooks et al., 2005)

Innovation projects are clearly hampered due to the technology gap. Currently South Africa is experiencing the adverse effects of the technology gap and much time and effort will need to be invested to reduce this technology gap in the future. In particular it was found that innovation projects are often not launched, because such problems are anticipated.

3.2.3 Innovative status

In business today, markets are increasingly of a global nature. Internet, global financial markets and increased foreign direct investment are all indicators of this global market. However, not all economies have the same levels of innovative and dynamic performance. And there seems to be no evidence that differences in national economic performance will become a thing of the past (Archibugi and Michie, 1997). This means that governmental action to improve a firm's competitiveness becomes more important. To determine a country's innovative and dynamic performance the concept of a National System of Innovation (NSI) was introduced by Freeman.

The innovative status of South Africa is described in the National System of Innovation (NSI).

National System of Innovation

Freeman introduced the concept of National Systems of Innovation to describe and interpret the performance of Japan after the Second World War. The body of

literature today, created by Freeman, Nelson, Lundfall and others, identifies the following aspects in defining the structure and explaining the behaviour and performance of nations (Archibugi et al., 1997):

- *Education and training.* Education is still believed to be largely national in scope. It is found that the distribution of students by discipline varies significantly across countries. Also the proportion of students actually participating in education varies (Mowery and Oxley, 1995).
- *Science and technology capabilities.* This characteristic of the NSI refers to the level of resources committed to formal R&D in a country in expenditures or manpower. This varies across countries.
- *Industrial structure.* The industrial structure of nations firms is an important factor in determining the nature of the economic activities a country. For instance, large firms undertake more basic research programmes. The competition on the local market differs as well.
- *Science and technology strengths and weaknesses.* Some countries have their S&T resources divided uniformly over all fields and some are specialized in only a few areas.
- *Interactions within the innovation system.* The way in which institutions interact with other actors in their country differs strongly among countries. For instance, governmental regulations can be strongly present or non-existent.
- *Absorption from abroad.* The propensity to engage in international technology transfer differs across countries.

Rooks and Oerlemans (2005) have determined that six characteristics can be employed to measure the NSI of South Africa. These are:

- Efficiency
- Education and training
- National R&D alliances
- External financial resources
- Governmental regulations
- Organizational rigidities

In the next section these six determinants will be discussed and compared to European figures. This data was retrieved from the comparable CIS (Europe) and the SAIS (South Africa) databases.

Efficiency

Efficiency is described as the relation between input and output. If a larger output is obtained with the same input, the efficiency is higher. In this case the input is innovation expenditures and the output is the percentage of innovating firms. In a research performed by the Department of Arts, Culture, Science and Technology (DACST) it was found that in South Africa little time and effort is spend in areas like

idea generation, R&D, prototyping and design of new products, services and or processes (DACST, 1999).

The innovation expenditures of South African firms are only 2.65% of sales, which is much lower than other countries. The R&D expenditures are only 1.55% of sales and the R&D workforce is only 1.8% of the total workforce. These figures are much lower compared to European standards.

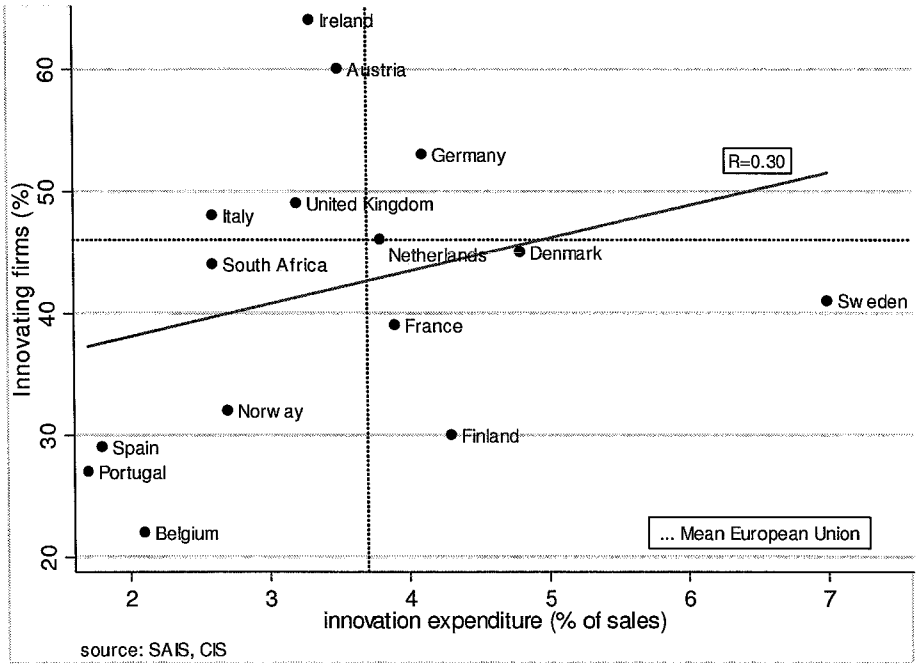


Figure 3.2 Efficiency of SA National Innovation System (source: Rooks et al., 2005)

In figure 2.1 the innovation expenditures of many European firms as well as those of South Africa, are measured against the percentage of innovating firms per country. South Africa has low input in terms of innovative expenditures and high output in terms of innovating firms. This is an indicator for an efficient national system of innovation.

Education and training

The following figure shows the percentage of firms that indicated that they had delays in innovation projects, or abandoned innovation projects, or experienced projects that did not start at all due to a lack of qualified personnel.

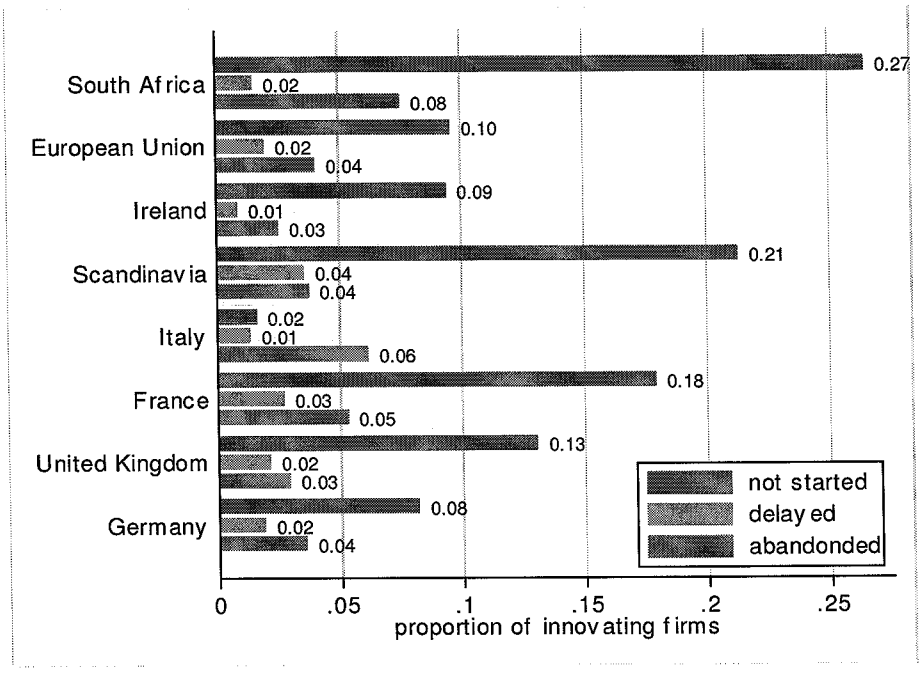


Figure 3.3 Delays or projects not started at all due to lack of qualified personnel (source: Rooks et al., 2005)

Firms indicated that there is a lack of qualified personnel in South Africa. In comparison with European firms, South African firms often indicate that a lack of qualified personnel is a main reason for the abandonment of innovative projects or this reason caused projects not to start at all. Scandinavian firms, surprisingly, show comparable results to South African firms. However, Scandinavia has a high technology level which may create a very high demand for qualified personnel. The score of South Africa will not be affected similarly, because South Africa is not a high technology nation (Rooks et al., 2005).

National R&D alliances

The following figure shows the percentage of firms with national, European and North American (US) innovative partnerships.

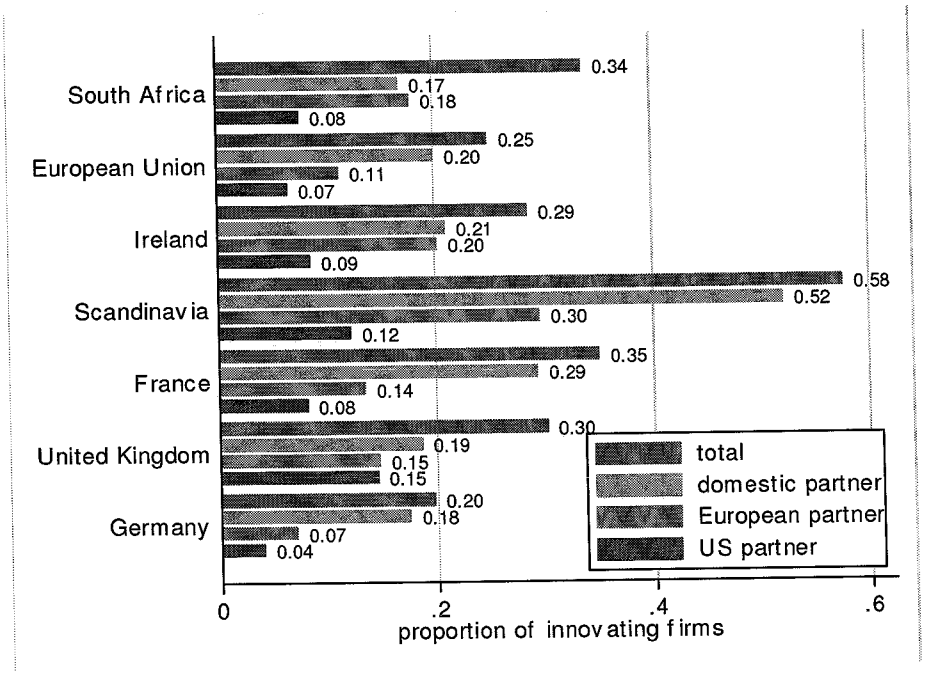


Figure 3.4 National innovative partnerships (source: Rooks et al., 2005)

Compared to European firms, South African firms have very few national innovative partnerships. About 17% of all innovative firms have partnerships with firms in South Africa. Surprisingly, South African firms have more European partners then European firms have themselves. The network of partnering within South Africa is underdeveloped. This could mean that there simply are not enough suitable partners in South Africa.

External financial resources

The following figure shows the amount of firms that indicated they had delays in innovation projects, as well as firms, which have abandoned innovation projects, or firms that reported that projects did not start due to a lack of external financial resources. Resources like governmental institutions, banks and other investors provide those financial resources.

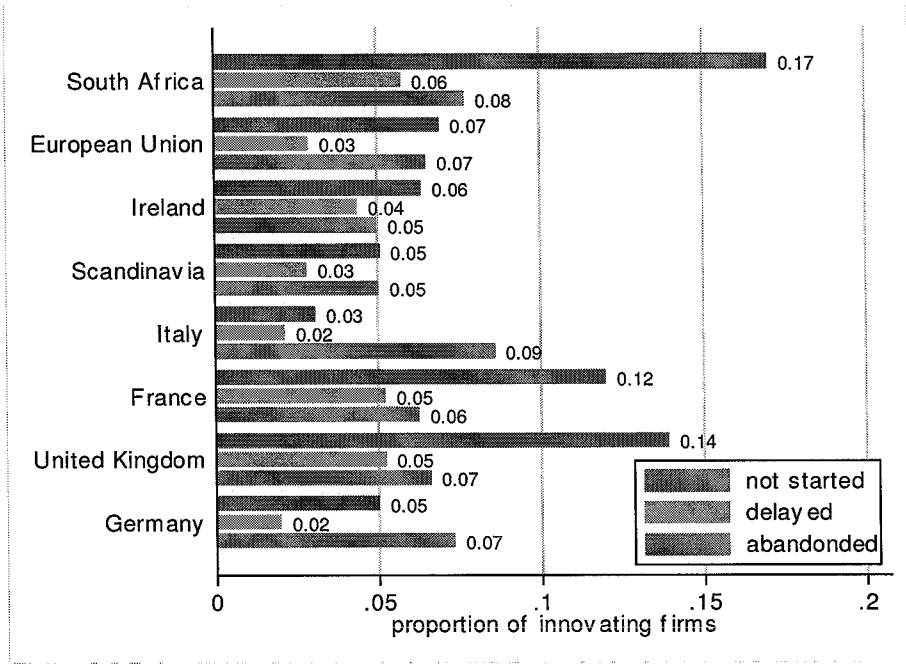


Figure 3.5 Delays or projects not started at all due to lack of external financial resources (source: Rooks et al., 2005)

In comparison with European firms South African firms often indicate that a lack of external financial resources is a reason for the delays in innovative projects or was the reason for projects not starting at all. Financial resources seem to be scarcely available in South Africa.

Governmental regulations

Restrictive governmental regulations can also cause firms to delay innovation projects or not start them at all. Regulation can for instance entail environmental regulations, zoning plans and taxes. The following figure shows the amount of firms that indicated they experienced delays in innovation projects, abandoned innovation projects or had the situation that innovations could not start at all due to restrictive governmental regulations. These regulations can entail: 'Red tape', Intellectual property rights, Legislation on standards, Anti-trust and cooperative rules and laws.

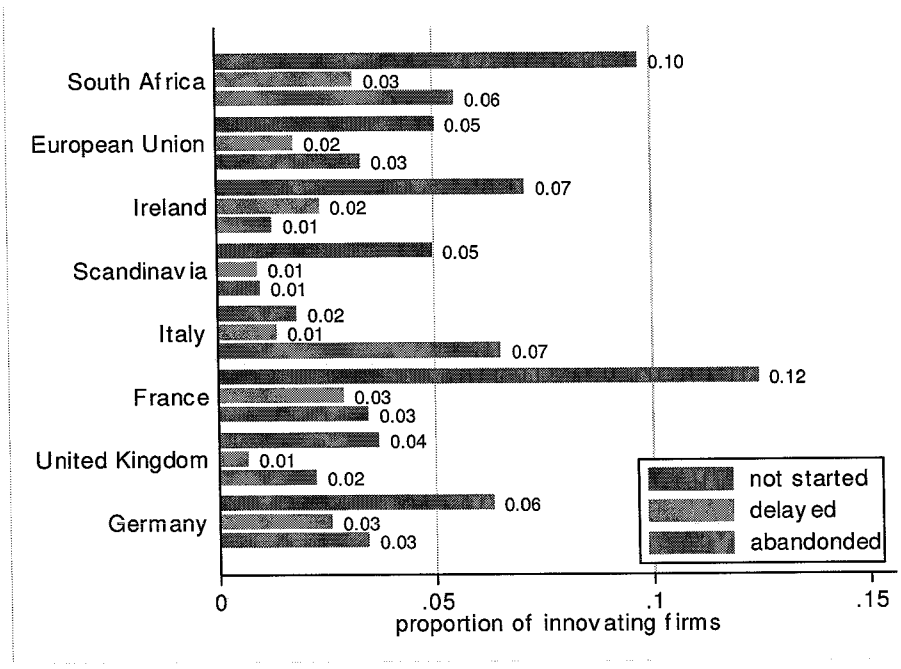


Figure 3.6 Delays or innovations not started at all due to restrictive regulations (source: Rooks et al., 2005)

In comparison with European firms South African firms often indicate that restrictive regulations were one reason for the delay of innovative projects or was a reason that resulted in projects not starting at all.

Organizational rigidities

Internal organisational rigidities, experienced mainly in large firms, can also cause firms to experience bottlenecks in their innovation process. The process of decision-making is often a bureaucratic process in larger firms. The following figure shows the amount of firms that indicated they have had delays in innovation projects, abandoned innovation projects or found themselves in the situation that innovation projects could not to start at all due to organizational rigidities.

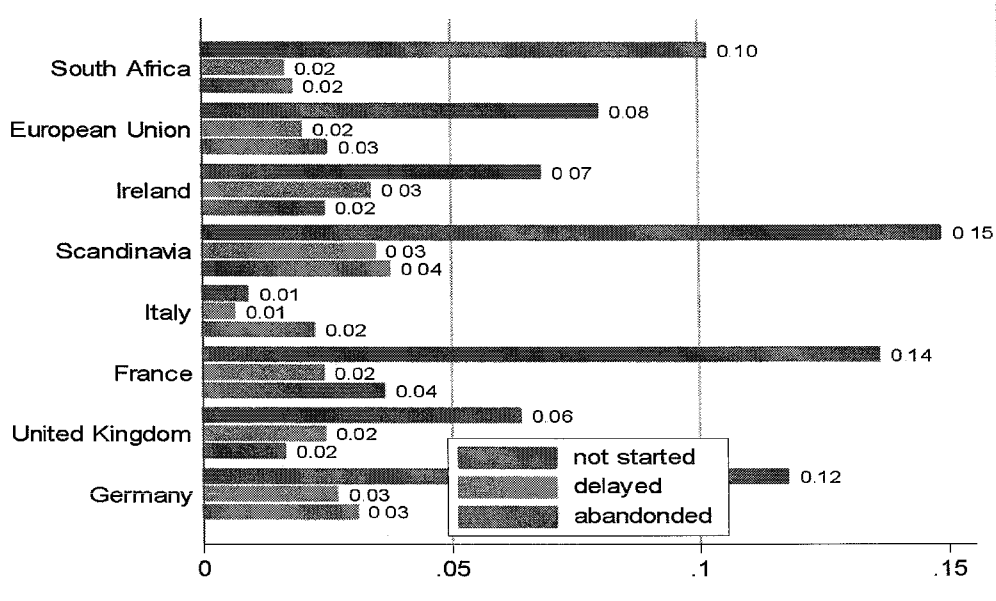


Figure 3.7 Delays or innovations not started at all due to organizational rigidities (source: Rooks et al., 2005)

South African firms indicate that their organizations are as flexible as firms in Europe. This determinant does not support that the national system of innovation in South Africa is underdeveloped.

Summary

Rooks and Oerlemans (2005) find that South Africa has a low input of innovative expenditures and a high output of innovating firms and can therefore be regarded as efficient. South African firms indicate that their organization is flexible as firms are in Europe. However, in South Africa there is a lack of qualified personnel and a lack of external financial resources. The South African government issues restrictive regulations that have a negative influence on innovative projects.

Another finding is that in comparison with European firms, South African firms have very few national innovative partnerships. It is obvious that at least parts of the NSI of South Africa are poorly developed.

3.3 Characteristics of South African firms

With the data collected by "SAIS 2001" and "SAIS 2001 revisited" a description of the main characteristics of South African firms are given. Main economic activities and sectorial distributions of firms are discussed and also size classes and regional distributions of firms are described. This data pertains to firms in manufacturing, service industries and wholesalers with ten or more employees, which had economic activities between 1998 and 2003. Therefore this data only describes a part of the South African economy.

3.3.1 Economic activities and sectorial distribution

To categorize the main economic activities of South African firms, firms were asked in the SAIS 2001 survey to indicate the economic activity in which the highest percentage of sales were realized. Economic activities are categorized in three areas: manufacturing, service industries and wholesale. Of the 601 firms, 63% are active in the manufacturing sector, 16% are service providers and 21% are in the wholesale business.

Main economic activity	Percentage (%)
Manufacturing	63
Wholesale	21
Services	16

Table 3.3 Economic activities (source: Oerlemans et al., 2003)

Eight sectors are considered to be mainly active in manufacturing. The wholesale sector is active in wholesale and commission trade and three sectors are considered service-orientated firms. This classification is in line with the Standard Industrial Classification (SIC) system used for South African statistics and the NACE industrial classification system used in the European Union. In figure 2.8 a more detailed picture is shown.

SIC code	NACE code	Description of sector	Reedbase code	Response
30	*15-16*	*Manufacture of food products, beverages and tobacco products*	*20, 21*	*36*
31	*17-19*	*Manufacture of textiles, clothing and leather goods*	*22, 23, 24*	*35*
32	*20-22*	*Manufacture of wood products, paper products, publishing and printing*	*25, 27, 28*	*20*
33-34	*23-26*	*Manufacture of fuel, chemicals, rubber, plastic and other non-metallic mineral products*	*29, 30, 31, 32, 33*	*90*
35	*27-30*	*Manufacture of metal products, machinery and equipment*	*34, 35, 36, 48, 40, 41, 42, 43, 44, 45, 46, 47, 51*	*126*
36-37	*31-33*	*Manufacture of electrical and optical equipment*	*37, 38*	*34*
38	*34-35*	*Manufacture of transport equipment*	*39*	*43*
39	*36-39*	*Manufacture of furniture; manufacturing n.e.c. and recycling*	*26, 49*	*26*
60-61	*50-51*	*Wholesale trade and commission trade*	*61, 62, 63, 64, 65, 66, 67, 68*	*106*
71-75	*60-64*	*Transport and Communication*	*72, 74, 75, 79*	*21*
80-83	*65-67*	*Financial Intermediation*	*82*	*17*
86-88	*72-74*	*Business services*	*44, 84*	*47*
		Total		*601*

Figure 3.8 Sector classification (source: Oerlemans et al., 2003)

The sectorial distribution of firms in the SAIS survey is visible in figure 2.12. This figure indicates of the size of each of these three sectors in South Africa. The Sectors manufacturing metal products, those manufacturing chemicals and the wholesale businesses are clearly the largest. These three sectors make up 55% of all firms. It

must be stated however, that many firms indicated that they are involved in activities in more than one area.

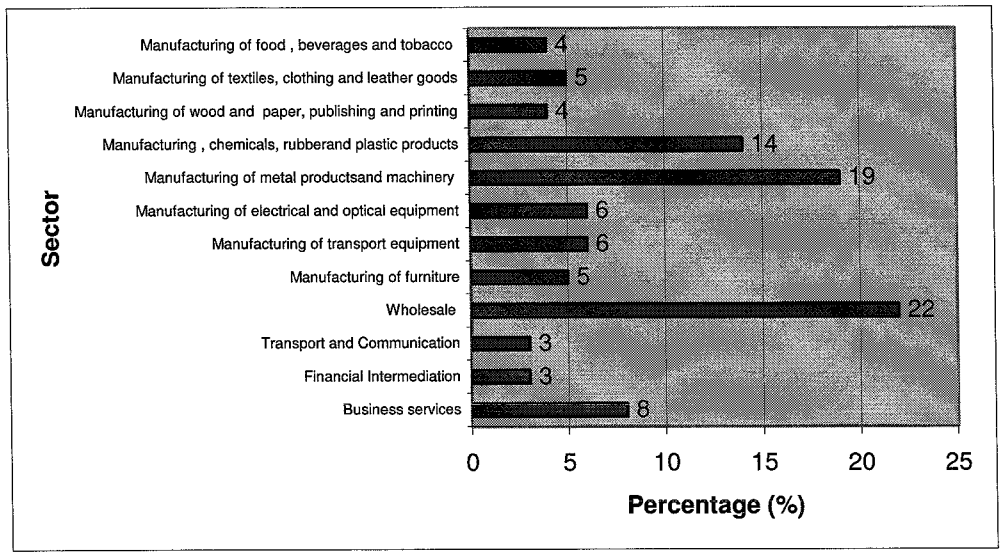


Figure 3.9 Sectorial distribution of firms (source: Oerlemans et al., 2003)

There is a large variation in sector size. The financial services sector represents 3% of the total response and the wholesale sector represents 22%.

3.3.2 Size class distribution

The majority of firms, 68%, have less than 50 employees, i.e. they are classified as small firms. 25% of all the firms have between 50 and 250 employees; and 5% of firms have 250 to 500 employees. Only 2% have 500 or more employees, and this grouping refers to the so-called large enterprises.

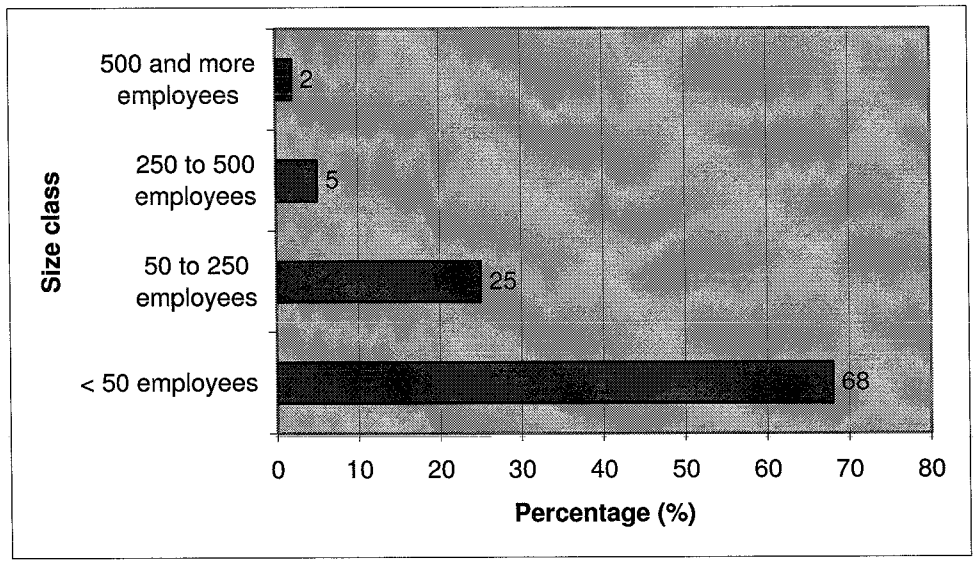


Figure 3.10 Size class distribution (source: Oerlemans et al., 2003)

3.3.3 Regional distribution

For the regional distribution South Africa is subdivided in its provinces. Economic activity is concentrated in a few areas in South Africa and therefore the regional distribution is divided in five regions: the four main provinces, with most economic activity and the remaining five provinces grouped as one region. These regions are:

- *Gauteng.* 66% of all the firms are operating in the Gauteng province. Johannesburg and Pretoria are big economic centres and are both located in this province.
- *Western Cape.* 13% of the firms are located in the Western Cape province, were in Cape Town the main activity is concentrated.
- *Kwazulu-Natal.* In Kwazulu-Natal province 12% of the firms are situated in and around Durban and Pietmaritzburg.
- *Eastern Cape.* In the Eastern Cape province 4% of the firms are located in and around Port Elizabeth.
- *Remaining provinces of South Africa.* The remaining 5% are spread out in the following provinces: Freestate, Northern Cape, Mpumalanga, Limpopo and North West province (see Figure 3.11).

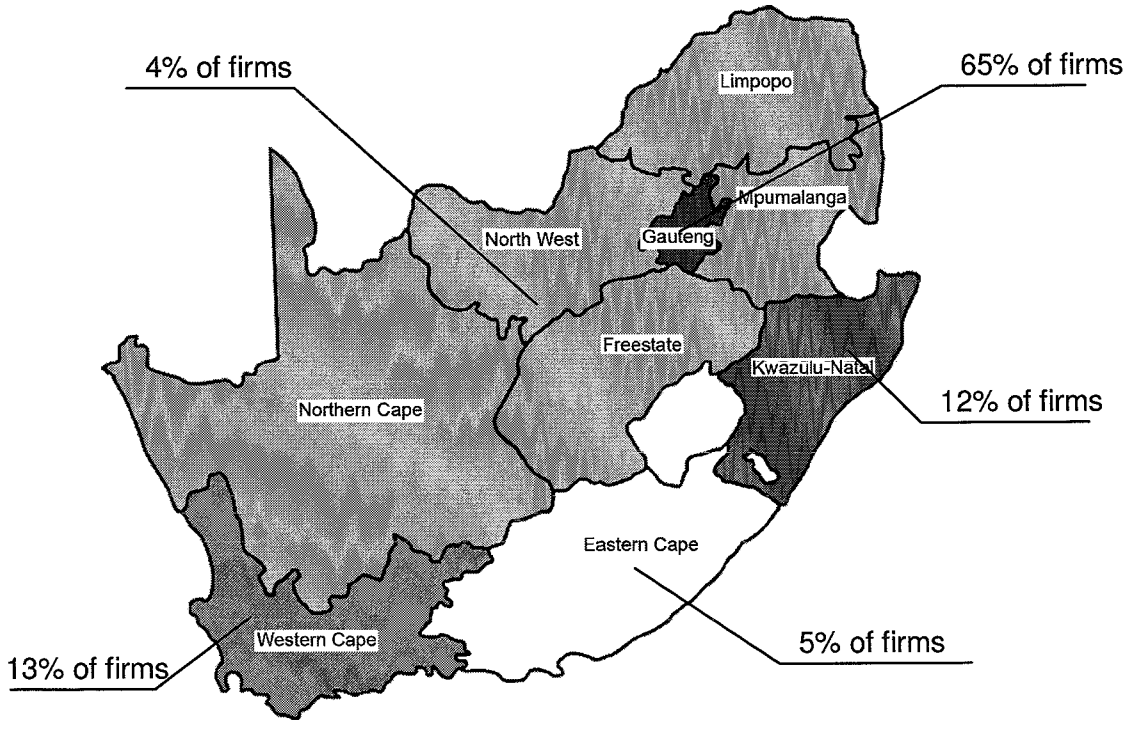


Figure 3.11 Regional distribution.

4 Methods

This chapter describes the data collection method employed to execute three research projects done on innovation in South Africa. The focus of these studies was to indicate what the status and impact of innovation is in South Africa. The following three sub-studies can be distinguished: (a) The effects of innovative partnerships, (b) innovation and job creation and (c) innovation regarding business performance. Chapter four has been written by Ronnie van de Thillart, Bernard de Veer and Robbert Westerhuis. The SAIS 2001 survey done in South Africa, forms the basis for this research project and it is discussed in paragraph 4.1. Further paragraphs discuss data collection and the responses (4.2), validation of data (4.3) to obtain the necessary data for the three research projects.

4.1 SAIS 2001

In 2001 a joint research group was formed between the *Department of Technology and Management* from the Eindhoven University of Technology in The Netherlands, together with the *Department of Engineering and Technology Management* from the Universiteit of Pretoria in South Africa. Their purpose was to give a comprehensive overview of the innovative behaviour and performance of South African firms in manufacturing and services sectors during the period 1998-2000. By means of a survey, data was collected from firms in the manufacturing, service and wholesale sector. This survey, the "South African Innovation Survey 2001" (SAIS 2001) was modelled on the European Community Innovation Surveys (CIS). The CIS was first employed in European countries from 1994 with the intention to gather information about innovative behaviour of European firms. In the years 1997 (CIS II) and 2002 (CIS III) the CIS was repeated.

The SAIS 2001 is based on CIS II and therefore the CIS can be seen as the foundation of standardization in this innovation survey. This standardization makes it possible to compare European results with South African results. The SAIS 2001 survey is the basis for this research.

4.1.1 Population and coverage error

The population in the SAIS 2001 was defined as:

> *All South African firms in manufacturing and service industries with ten or more employees that conducted economic activities in the period 1998-2000.*

Industrial sectors covered were: manufacturing, wholesale and commission trade, transport, storage, communications, financial intermediation and business services. This classification is in line with the Standard Industrial Classification (SIC) system used for South African statistics and the NACE industrial classification system used in the European Union. These firms were randomly selected from the Reedbase

database, which consists of 16,931 firms with a known number of employees. The Reedbase is a commercial database and firms have to pay to be included. Therefore the database does not reflect the true size-distribution of South African firms. In South Africa public databases are not yet available. The Manufacturing Census 1996 contains precise information about the distribution of size groups of the manufacturing firms in South Africa. By comparing Reedbase with the Manufacturing Census 1996 database, it was found that small firms were underrepresented in the Reedbase database (table 4-1). This is called the "coverage error". No information about the coverage error of the service sector was known. The coverage error for the manufacturing sector was used to correct the size distribution in the service sector. To address discrepancies the population figures of the acquired data were weighted. The information is now representative for the South African industry firm size distribution. The findings now "accurately describe innovation and innovative activities of South African business life" (Oerlemans et al., 2003).

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

Table 4.1 Comparison between Census Manufacturing 1996 and Reedbase (Source: Oerlemans et al., 2003).

Stratified sampling was used as the sampling technique. In comparison with straightforward sampling techniques, stratifying can reduce a sampling error. The European CIS was divided in the same strata and their design was proven successful. It also improves the comparability of the SAIS with the CIS.

The SAIS 2001 population was divided into three strata (see table 4-2): (1) firms with 11 to 20 employees, (2) firms with 21 – 50 employees and (3) firms with more than 50 employees. The numbers of firms fitting in these strata is also presented, together with the mean number of employees.

Stratum	Number of firms	Mean number of employees
11-20 employees (n_1)	2166	15.99
21-50 employees (n_2)	4611	35.04
More than 50 employees (n_3)	3656	769.59

Table 4.2 Stratum size, number of firms and mean (Source: Oerlemans et al., 2003).

Out of these three strata respectively 768, 2606 and 3665 firms were randomly selected. This means that the total sample consisted of 7039 firms. The distribution is resumed in table 4-3.

Stratum	N_l	Sample size
n_1	2,166	768
n_2	4,661	2,606
n_3	3,665	3,665
Total	10,492	7,039

Table 4.3 Distribution of sample size (Source: Oerlemans et al., 2003).

4.1.2 Response and non-response SAIS 2001

To collect the required information, questionnaires were mailed to the managing directors of the firms. The questionnaire was accompanied with an introduction letter by the research team and a recommendation letter written by Dr. B.S. Ngubane. At that time Dr. B.S. Ngubane was Minister of the former Department of Arts, Culture, Science and Technology of South Africa. There was also an option for respondents to complete the questionnaire on the SAIS 2001 website. The survey started in December 2001. Because of a very low response rate the research team decided in May 2002 to change the data collection strategy. The postal surveying method was stopped and direct surveying methods were chosen. The research assistants continued the survey with telephonic interviews and by sending e-mails. Eventually 601[9] of the 7,339 firms returned the questionnaire. This corresponds with a response rate of 8.2%. Small firms responded slightly below expectation. This is shown in table 4-4.

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

Table 4.4 Size classes, Distributions of response and sample (source: Oerlemans et al., 2003)

In spite the fairly high amount of absolute responses the relative amount of firms that responded, is rather low. To make sure that there was no structural error in the response, a Non-Response Survey was carried out. This was done to examine if the firms who cooperated could be regarded as representative for the South African business community.

The size of the non-response sample was based on the Dutch CIS (1994) non-response survey. 5% of their sample size was used for the non-response survey. If this percentage is applied to the SAIS 2001 non-respondent sample, 320 non-

[9] In SAIS 2001 617 firms filled in the survey. Information from four firms was lost and after data verification twelve duplicates were found.

respondents should be selected. Eventually 416 firms responded, what corresponds with 129% of the target value.

The respondents were asked three questions:

1. Why they did not complete the questionnaire
2. The continuity of Research and Development activities
3. Whether or not a firm had technological innovations in the period 1998-2000.

The answers of the first questions, which were given by the respondents, are shown in table 4-5. More than 50% of the firms mentioned that they did not receive the survey. A possible explanation is that the questionnaires were sent to the managing directors of the firms, while the respondents of the non-response survey had other positions in the firm and hence never saw the questionnaire. Lack of time was frequently mentioned as a reason for not filling in the questionnaire. Another reason was that 'I never fill in questionnaires' (3%), or it is of 'no use for the company' (5%) and 'other reasons' (7%).

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

Table 4.5 Reasons for non-response to the SAIS 2001 survey (source: Oerlemans et al., 2003)

The answers on the second question are shown in table 4-6. This question was about the continuity of Research and Development activities in responding and non-responding firms. The response and non-response group hardly differ and a statistical test (the Mann-Whitney U-test) shows that it could be assumed that the groups are identical with respect to the continuity of their R&D activities (p=0.46).

Continuity of R&D	Response group	Non-response group
More or less continuously R&D	196 (37%)	164 (40%)
Occasionally R&D	154 (29%)	119 (29%)
Not conducting R&D	178 (34%)	132 (31%)
Total	528 (100%)	415 (100%)

Table 4.6 R&D activities for the response and the non-response group (Oerlemans et al., 2003)

The answers to question three is shown in table 4-7. This question was about whether or not a firm had any technological innovations in the period 1998 – 2000. In spite of the fact that the differences are somewhat larger, the non-response group contains more innovators (58%) than the response group (54%), the difference is not statistically significant (p=0.17).

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

Table 4.7 Technological innovations; response and the non-response group (Oerlemans et al., 2003)

The conclusion of the non-response survey was that the information obtained via the SAIS 2001 gave a true reflection of the South African industry.
All steps concerning the data collection and response are summarized in figure 4.1. Figure 4.1 visualizes the methods used, from the sampling frame to the weighing of the results.

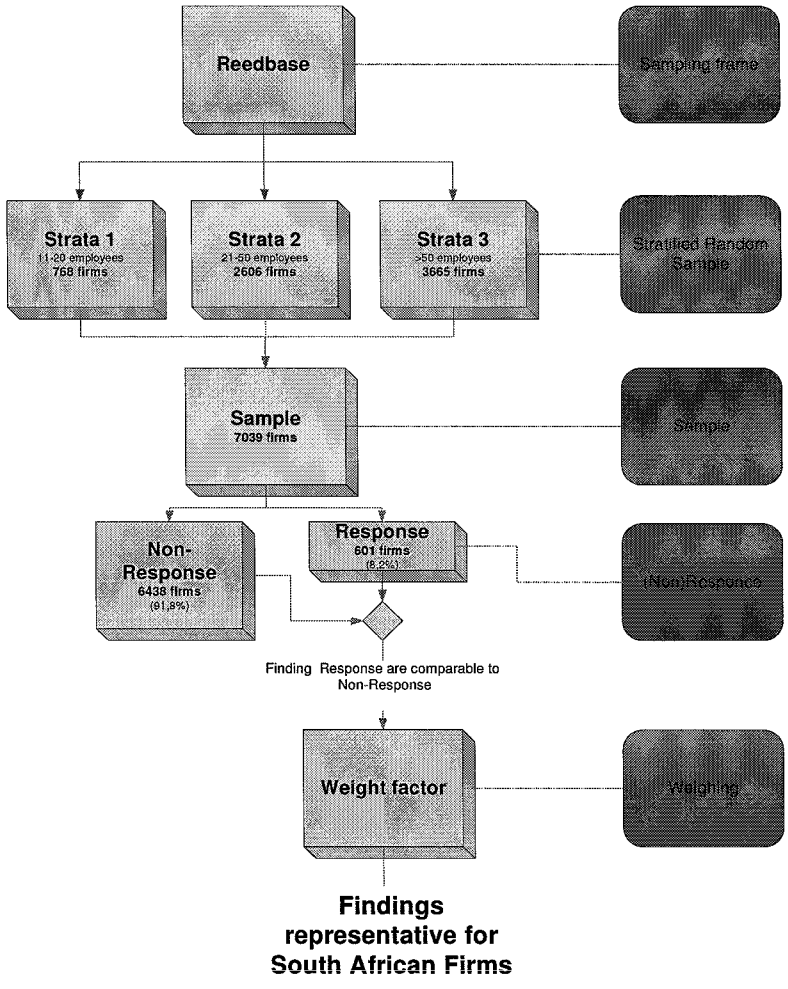


Figure 4.1 Datacollection and respons

4.2 Data collection and response "SAIS 2001 revisited"

Data collected in the survey of 2001 was complemented with new data. A short version of the SAIS 2001 was repeated in 2004 under the name "SAIS 2001 revisited". The firms that cooperated with the SAIS 2001 were asked for their

cooperation again. The fact that the research has two points in time where data was collected makes the research a longitudinal design. More specifically this research can be viewed as a panel-research. This is a type of longitudinal study that uses the same research units, in this case the 601 firms of SAIS 2001, at different points in time.

The big advantage of a longitudinal survey design is that it opens opportunities to make statements on causal relations since the same firms are included in the dataset (Breakwell, Hammond and Fife-Shaw, 2000). However, a longitudinal survey has some disadvantages. The main problem is the danger of a low response mainly caused by two factors. The first is the "drop out" of firms. Many firms will have left the market due to a bankruptcy or will have merged or changed making the firm incomparable to the previous situation. Secondly there may be a danger for a low response if respondents are unwilling to cooperate a second time. The response "Once is fine, but not more" is often heard in a longitudinal research. The other major disadvantage is the risk of a biased sample. Firms who cooperate in the same survey more than once, may be interested in the topic, or may be more compliant, or may have specific characteristics, which result in a biased sample. Therefore a high response rate is very important. The last disadvantage is the fact that the anonymity of respondents cannot be claimed since you will need to have some way of identifying respondents for re-contacting (Seale, 2004). It is evident that a high response in a longitudinal research is of great importance.

To gather the required information a telephone-based questionnaire was composed. A telephone-based questionnaire was used since earlier researches with written questionnaires did not give the expected results. In a related study, Clerx experienced great difficulties in gathering responses on his written questionnaire (Clerx, 2005). Three explanations for this low response can be distinguished. The first is the fact that written questionnaires are a passive data collection method. The researcher is not actively persuaded to respond to the survey. Secondly, the written questionnaire consisted of too many topics and questions. Thirdly, there is a corporate atmosphere in which surveys are badly accepted. SAIS 2001 also used a written questionnaire where eventually 8.4% of the firms cooperated. The same explanations for the low response hold for the SAIS 2001 survey. Additionally, November (time of data collection SAIS 2001) is an awkward month in the year for data collection since summer holidays in South Africa are in December.

During a telephone based survey, interactive communication is possible. The interviewer can emphasize the importance of the survey to win someone over. The expectation was that this method would obtain a higher response rate than with a written survey. Since no time or resources were available to repeat the entire research, and in an attempt to obtain higher number of responses, the number of questions in SAIS 2001 revisited was limited to 9. This low number of questions also limits the time a respondent had to complete the survey. The number of questions in SAIS 2001 revisited was limited to 9. This was done to limit the time a respondent had to complete the survey. The questions were relatively easy to answer and the

survey could be completed within 5 minutes. This encouraged respondents to cooperate.

The data collection started in the beginning of September 2004, and was divided into 4 steps:

- Step 1: Verifying firm contact information
- Step 2: Composing a survey framework
- Step 3: Data collection
    - 3.1: Telephone based questionnaire
    - 3.2: Written questionnaire
    - 3.3: Covering letter
- Step 4: Analysing results

4.2.1 Step 1: Firm contact information

Before the start of SAIS 2001 revisited, all the firms' contact information had to be verified. Some firms were marked as "non-existent" because the company names had changed, or contact details had changed (i.e. telephone numbers or addresses). General information about all the firms were checked and, where necessary, updated. This was done with the use of three different databases: the Braby's Red Disc database on CD-ROM, the South African Yellow Pages internet site[10], and the Worldwide Kompass internet site[11]. These databases were used to complement and update the SAIS 2001 database as much as possible. If phone numbers could not be retrieved with these databases they could be updated using the South African telecom provider TELCOM. Calling a service number of TELCOM provided access to the best-updated database concerning telephone numbers. This was however so inefficient and time consuming that the three methods above were first exhausted.

4.2.2 Step 2: Survey framework

Since difficulties were expected in retrieving high responses, a considerable amount of time was invested in composing a survey framework. In this framework the procedure is drawn up to make first contact with the contact person. In figure 4.2 and 4.3 the telephonic procedure is presented.

[10] www.yellowpages.co.za
[11] www.kompass.com

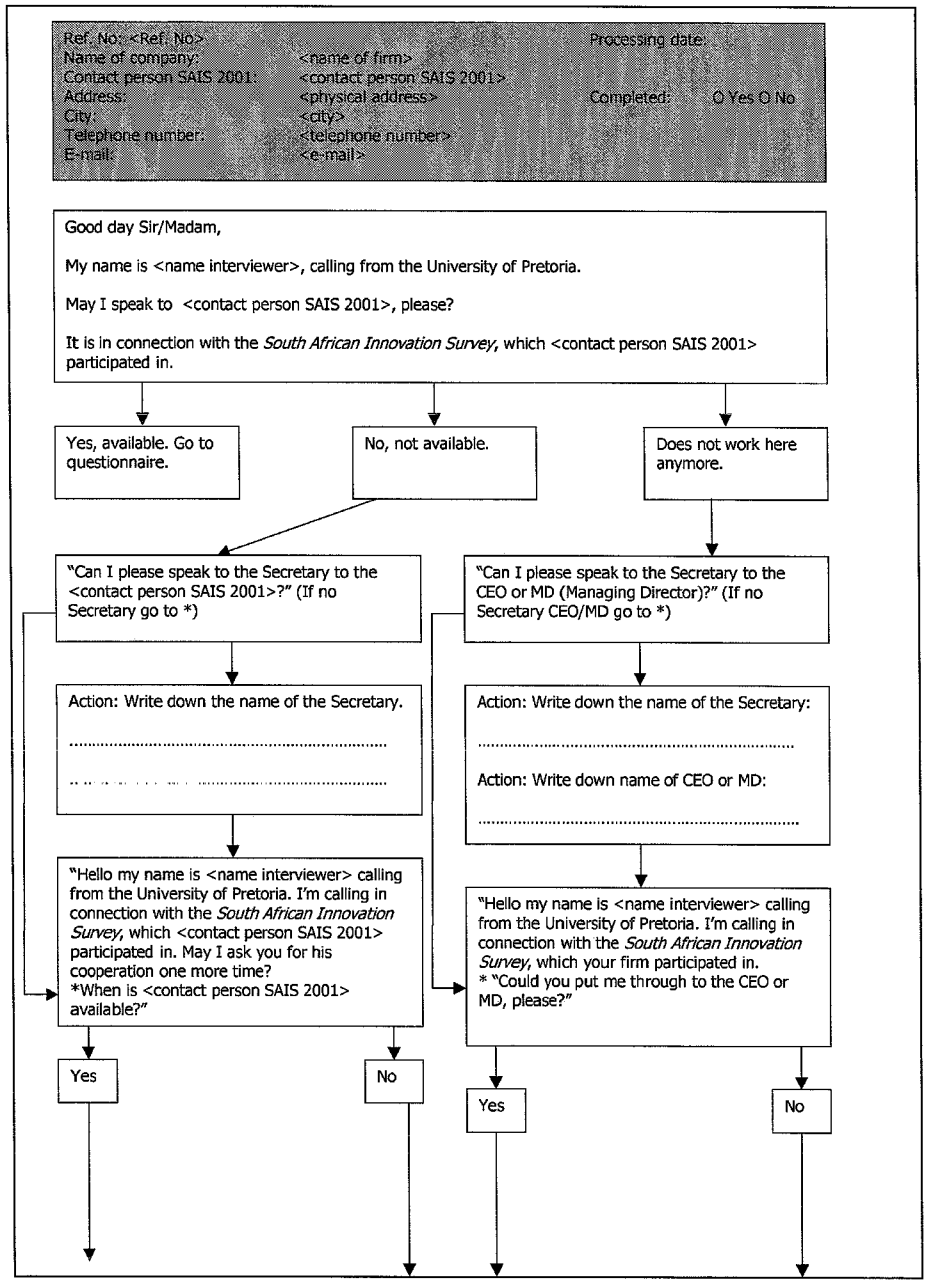


Figure 4.2 Telephonic framework (1)

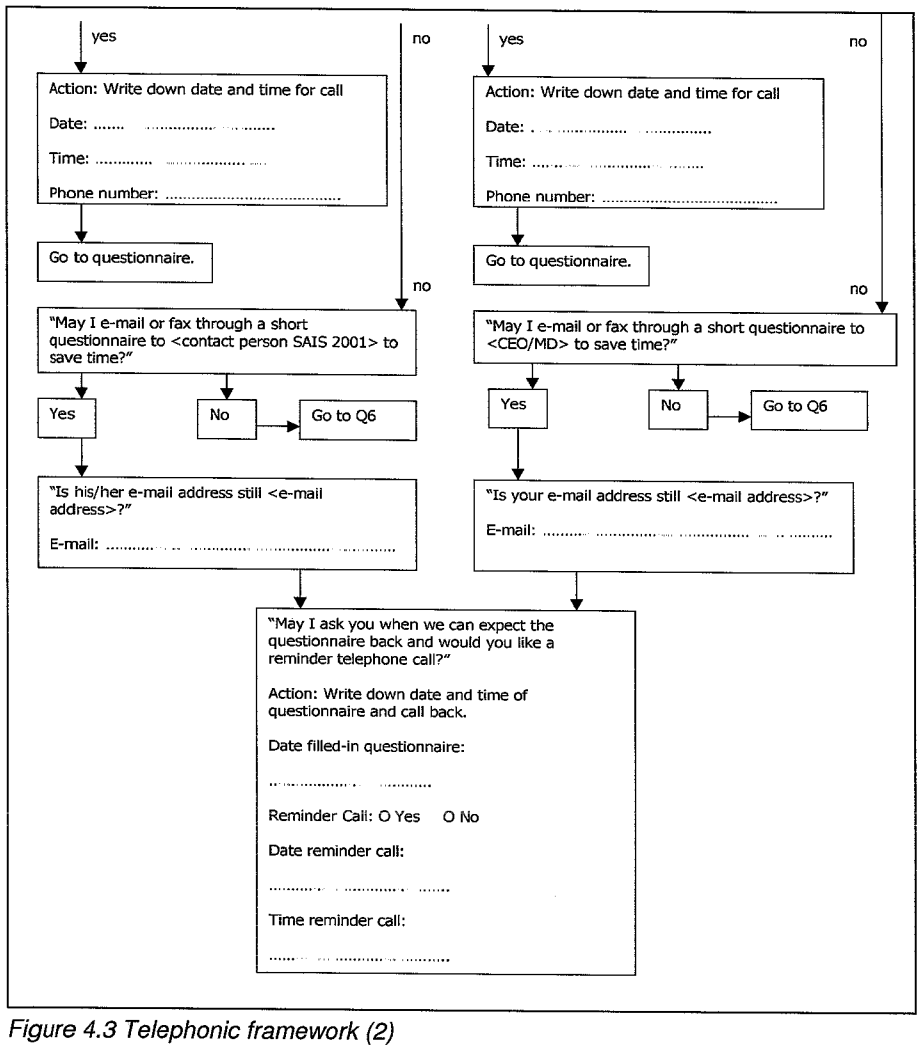


Figure 4.3 Telephonic framework (2)

A considerable amount of time was invested in first making contact with the respondent using the SAIS 2001 list. Most of the times the caller was put through to the personal assistant (secretary). The personal assistant was asked for the availability of the respondent to make an appointment for further contact. The respondent was unavailable on the first call in most circumstances (70% of all calls). If the respondent of SAIS 2001 was no longer with the firm, the CEO or Managing Director was contacted via his or her personal assistant. In 10% of the calls this method was used. This means that in only 20% of first calls, first contact with the right respondent was made. On average a firm was called 3 times. The greatest portion of time was invested in making contact with the respondents.

As a result of the first call the respondents name was known and also his or her availability. This resulted in many responses in the second and third call. Sometimes personal assistants requested a questionnaire by e-mail or fax. The decision was made to give respondents this opportunity. In this way the respondent could complete the questionnaire at his or her own leisure. If all attempts fail to get the required responses by phone, e-mail and fax based questionnaires (written questionnaire) were also offered.

To prevent that the written questionnaire would be 'forgotten', a reminder telephone call was scheduled. A spreadsheet with firms that had to be called back, firms that were mailed, firms that were faxed and firms that completed the questionnaire was updated continually.

4.2.3 Step 3: Data collection

The telephone-based questionnaire was always the preferred way of collecting the data. E-mail- or fax based questionnaires were used reluctantly. These questionnaires did not have the advantages of interactive communication.

Telephone-based questionnaire

Composing a questionnaire that provides sufficient information to base three researches on and restricting the questionnaire to only 9 questions provided some challenges. Selections had to be made to restrict the number of questions to a bare minimum. In this paragraph the questions in the questionnaire will be elaborated one by one.

Introduction

The interviewer starts by introducing him- or herself and clarifies the importance of the research (see figure 4.4). The respondent is reminded about their former cooperation with SAIS 2001 and that the final report of that research was presented to the Minister of Science and Technology at that time. This may persuade him or her to participate once again.

Good day Sir/Madam,

My name is *<name interviewer>*. I am a member of a joint research team [from the Department of Engineering & Technology Management,] from the University of Pretoria and the University of Eindhoven from the Netherlands. A few years ago you *<contact person>* cooperated with the SAIS2001 research. This SAIS 2001 report was presented to the Minister of Science & Technology.

As a sequel to the SAIS2001 research we explore to what extent innovation has contributed to economic development and employment growth in South Africa. For this reason we are doing a short telephone based survey. Because of your cooperation on the first research, your response is exceptionally valuable.

Q: "May I ask you 8 short questions for this research?" (Yes, go to questionnaire. No, "Can I call you back at another time?")

No: "Or would you prefer to receive an e-mail or fax to complete the survey at your leisure?"

Figure 4.4 Introduction phone based questionnaire

The interviewer asks if this is a convenient time to complete the questionnaire. If this is not the case, a telephonic appointment can be made at a later time.

Employment

The goal of question 1 is:

- To determine the number of employees in 2003.
- To double-check the number of employees in 2000.
- To determine the reason for the employment changes and the education levels where this change mainly occurred.

"First I would like to verify some firm specific data. Is your firm still located at <*address*> in <*city*>?"

Q1a: What was the number of employees in your firm in 2003?

Q1b: "In your response to the SAIS 2001 survey you indicated the number of employees to be <*number of employees 2000*> in the year 2000.

Is it correct that there is an increase/decrease trend in employment? Could you indicate a clear reason for this employment change?"

Q1c: "Did this trend occur at all education levels? (lower education/operator level, Medium education/supervisor level and higher education/level-jobs?)"

Figure 4.5 Q1 phone based questionnaire

Verifying answers of the SAIS 2001 survey was an important tool to acquire valid longitudinal information. This contributed to a higher quality of obtained data. Some respondents give information that only concerns a part of the firm (division or department), which makes a comparison between 2000 and 2003 impossible. An example of the verification of answers is visible in question Q1b. To make sure that employment increased or decreased between 2000 and 2003, the respondent was confronted with the number of employees that was indicated in 2001. The respondent can verify this data on the spot or revise it.

Innovativeness

Question 2 referred to the innovativeness of firms concerning products and services. The following questions were asked.

Q2a: "Did your firm introduce any technologically new or improved products or services in 2003?"

No → go to 3

Q2b: "Were these "step-by-step" changes or "drastic changes" in your product or services?"

Q2c: "What is the sales percentage of/from the drastically changed products or services in 2003?"
"What is the sales percentage of/from the step-by-step changed products or services in 2003?"

Q2d: "Where these products/services new to the market? Or have competitors already introduced such products?"

Figure 4.6 Q2 phone based questionnaire

Question Q2a was asked to assess what percentage of firms can be considered to be innovative in 2003. It cannot be used to distinguish trends in innovative performance since the same questions in SAIS 2001 were asked over a period of 3 years. To distinguish this trend the innovative sales figures of question Q2c was

used. The last question was asked to determine whether the innovation was not only new to the firm, but also new to the market.

Question 3 refers to the innovativeness of firms concerning process innovation.

Q3: "Did your firm introduce any technologically new or improved production processes in the period 2003?"

Figure 4.7 Q3 phone based questionnaire

Economic performance

To establish the economic performance of firms the total sales of the year 2003 was asked. Again the information of SAIS 2001 was verified. Information on sales can be confidential and managers are often reluctant to disclose this information, especially over the phone. Therefore the respondent was offered the opportunity to limit the supplied information to indicate an increase or decrease percentage of sales growth.

The next few questions concerns the economic performance of your firm. Q4: "What were the total sales in 2003?" In SAIS 2001 you indicated that the total sales of your firm were <total sales 2000>. It is correct that there is an increase/decrease trend in sales?" Or if you don't have the figures off hand would you say there was an increase or decrease in sales over the last 3 years? Could you indicate this as an percentage?"

Figure 4.8 Q4 phone based questionnaire

The second measure of economic performance, more specific the performance on foreign markets, was determined with the export ratio of firms.

Q5: "What were the exports as a percentage of total sales in 2003?" In SAIS 2001 you indicated that export, as a percentage of total sales of your firm were <export 2000>% in the year 2000. It is correct that there is an increase/decrease trend in exports?" Or if you don't have the figures off hand would you say there was an increase or decrease in exports over the last 3 years? Could you indicate this as an percentage?"

Figure 4.9 Q5 phone based questionnaire

Conclusion

Finally the respondent was thanked for there time and the assurance was given that all information provided would be handled confidentially. Question 6 was asked if the respondent was not willing to cooperate with the survey.

This was the last question. I would like to thank you for your cooperation on behalf of the department technology management of the university of Pretoria! Finally I would like to reconfirm that the provided data will be dealt confidentially. Would you like to receive an e-mail with the results of the research?

Q6: Would you kindly state why you do not want to cooperate with the survey?

Figure 4.10 Q6 phone based questionnaire

One standard datasheet was composed to gather the notes and answers from a firm. The firm's phone number and name was printed on top of the sheet. As has been said previously, firm information from the year 2000 was verified during the interview. Therefore this information was also printed on the datasheet. Inserting the firm specific information in the standard datasheet was a fully automated process. By linking Microsoft Word and Microsoft Excel, the firm specific information out of an Excel database was automatically inserted in the Microsoft Word datasheet. A couple of advantages accompany this method. All information of a particular firm was on one sheet. Using one sheet was also labour saving.

<Participation number> - <Name firm>

Phonenr.	*<Telephone number>*	
Contact person	*<Name contact person>*	
Secretary		
Call back time	**1** **2** **3** **Date:** **Time:**	
E-mail	*<E-mail address>*	
Fax		

1	**Firm location**	*<Address>* *<City>*	
	Employees 2000:	**Employees 2003:**	
	<Employees 2000>	**Decrease / Increase** **Education level:** **Low / Medium / High**	

2	**New/Improved Products/Services**	**Yes** **No** **(Step-By-Step / Drastic / Both)**
	Sales% contributed *<Step-by-step changes 2000>* *<Drastic changes 2000>*	**Step-By-Step 2003:** **Drastic 2003:**
	New market	**Yes** **No**

3	**Process innovation**	**Yes** **No**

4	**Total Sales 2000**	**Total sales 2003:**
	<Total sales 2000>	**Percentage of sales growth 2000-2003:**

5	**Exports% Sales 2000**	**Exports as percentage total sales 2003:**
	<Export as percentage of total sales 2000>	**Percentage of export growth 2000-2003:**

Results E-mail		
Call Back		
Caller	Rob	
	Ronnie	
	Bernie	
	Anthea	
	Daline	

No cooperation:

O Lack of time
O It of not of use to the company
O I never fill in questionnaires
O Other:

Figure 4.11 Datasheet

Written questionnaire

Not all respondents were willing or able to provide the data by phone. If requested there was a possibility to complete the questionnaire by use of e-mail or fax. This means that data of SAIS 2001 could not be verified on the spot. The survey on paper therefore differs slightly from the telephone-based version. In the fax and mail questionnaire three methods were used to verify the data supplied. Employment figures were checked by asking for the exact number of employees and than asking if there was an increase of decrease of employment over the last three years. The same was done with sales and export data. If the provided growth figures differed to the calculated growth figures between SAIS 2001 and SAIS 2001 revisited, the firm was contacted a second time. This manner allowed researchers to address discrepancies in the data.

E-mails were sent from one specially made E-mail address (SAIS2004@up.ac.za). In this way all responses were gathered centrally. The same was done with faxes. All faxes were sent by computer allowing faxes to be easily traced. The e-mail questionnaire is included in Appendix B. The time and the date of sending were monitored. If a firm did not respond in one week, the firm was approached a second time. The setup of the fax and e-mail, the professional way of approaching the firms and keeping up the pressure in case of non-response, lead to a contribution of many responses. The data collection started in the beginning of September and was concluded in November 2004.

Covering letter

If requested, a covering letter was sent to the respondent from the Head of the Department of Engineering and Technology Management. The covering letter gives the respondent the possibility to verify the information provided by a caller. It also describes the background and importance of this research. The letter is signed by the professor to emphasize the validity of this document. The covering letter is included in Appendix A.

A covering letter was also included with the fax and mail questionnaires. The covering letter is available in different formats to suit the respondent's wishes (Microsoft Word, PDF and fax).

4.2.4 Step 4: Response and non response

Of the 601 firms, 16 could not be traced because of a lack of contact information and 19 firms had gone out of business between 2000 and 2003. That left 566 firms who were able to respond to the questionnaire. The response was high, 97.7% of the firms responded. The choice for a telephonic survey turned out to be the right one. 80% of the responses were contributed by the telephonic survey. And 17.7% by e-mail and fax surveys. That means that only 13 firms indicated that they did not want to cooperate. In 80% of instances the reason for the non-cooperation was a lack of time. Other reason were 'I never fill in questionnaires' (5%), it is of 'no use for the company' (5%) and 'other reasons' (10%).

13 firms merged with other firms or were taken over. These firms will not be a part of the data analysis, since data from 2003 cannot be compared with the situation in 2000. An overview of all this information is visible in figure 4-12.

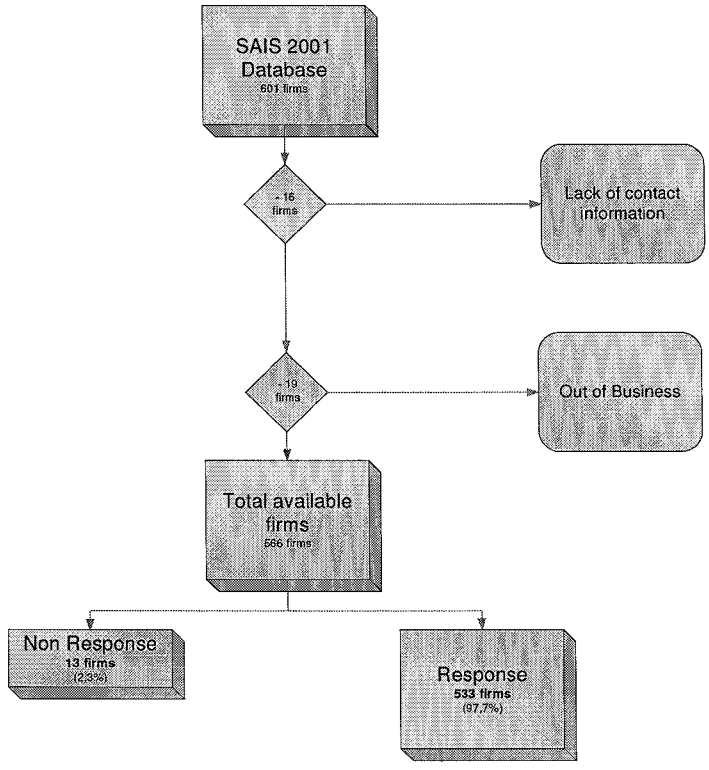


Figure 4.12 Response rate

All the firms provided data, which had to be inserted in an excel database. During this process copy failures had to be reduced to a minimum. Therefore a Microsoft Access form was designed as illustrated by Figure 4-13. It made the data import simpler, failures were reduced and afterwards the verification was easier.

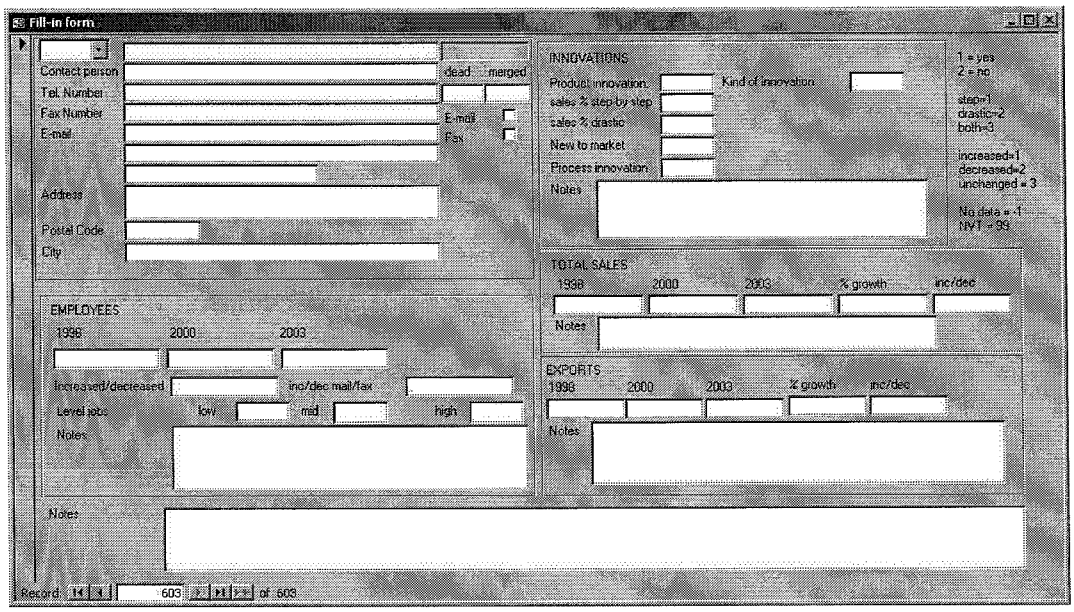


Figure 4.13 Access data sheet

After finishing the data entry and the data verification, the Access data could be easily converted to an excel database.

4.3 Validation of data

With the data collected by 'SAIS 2001' and 'SAIS 2001 revisited' a description of the main characteristics of South African firms are given. The obtained data will be compared with national South African means according to Statistics South Africa. This will give an interpretation of the validity of the data and the latter conclusions.

4.3.1 Employment

Employment figures are available for the years 2000 and 2003. This data is obtained from the SAIS 2001 survey and the "SAIS 2001 revisited" survey. With this data employment growth over this period can be calculated. This was done for all firms combined, per sector and per size class.

Sector	Employment growth between 2000 and 2003 (SAIS 2001/ SAIS 2001 revisited)	Annual % employment growth (SAIS 2001/ SAIS 2001 revisited)	Annual % employment growth (StatsSa)
Manufacturing	4.4	1.46	
Food, beverages & tobacco	0.1	0.03	--
Textiles, clothing & leather products	-1.0	-0.3	--
Wood and paper (products) & publishing	15.6	5.2	--
Chemicals, rubber and plastic products	-0.4	-0.13	--
Metal product, machinery, and equipment	7.1	2.3	--
Electrical & optical equipment	10.1	3.4	--
Transport equipment	11.2	3.7	--
Furniture, and n.e.c.	-6.6	-2.2	--
Wholesale	4.1	1.3	--
Services	0.25	0.1	--
Transport and communication services	26.9	8.9	--
Financial intermediation services	14.3	4.7	--
Business services	-11.4	-3.8	--
Total	3.8	1.2	1.2

Table 4.8 Employment Growth

Between 2000 and 2003 a yearly employment increase of 1.2% is found. These figures correspond with the Statistics South Africa (StatsSa, 2002). In the survey of 2002, employment in the measured component of the formal non- agricultural business sector increased by 1.2% between December 2001 and December 2002 (StatsSa, 2002). The StatsSa survey is a cooperation between Statistics South Africa, the citizens of the country, the private sector and government institutions [12].

4.3.2 Sales

In 2001 and in 2004 firms were asked to indicate the total sales of their firm of the previous year at the year-end. From this data growth figures can be calculated between 2000 and 2003. The total sales growth of all firms, per sector, per size class and economic activity is calculated.

[12] Statistics South Africa. Source:www.statssa.gov.za

Sector	Annual % Sales growth (2000-2003) (SAIS 2001/ SAIS 2001 revisited)	Annual % Sales growth per economic activity (2000-2003) (SAIS 2001/ SAIS 2001 revisited)	Annual % Sales growth per economic activity (2000-2003) (StatsSa)
Manufacturing	26.4	8.8	8.9
Food, beverages & tobacco	5.9		
Textiles, clothing & leather products	4.1		
Wood and paper (products) & publishing	12.5		
Chemicals, rubber and plastic products	8.5		
Metal product, machinery, and equipment	9.1		
Electrical & optical equipment	12.5		
Transport equipment	10.3		
Furniture, and n.e.c.	8.3		
Wholesale	31.8	10.6	--
Services	15.4	5.1	--
Transport and communication services	3.2		
Financial intermediation services	5.7		
Business services	5.2		
Total	8.6	8.6	--

Table 4.9 Sales Growth

Total sales increased between 2000 and 2003 with 8.6% each year. This is comparable with the findings of Statistics South Africa[13]. Between 2000 and 2003 total sales per month of the manufactured products of all manufacturing firms went from R47.936.871 in December 2000 to R60.825.214 in December 2003 (StatSa, 2003). This means a growth of 26.9 % between 2000 and 2003, and a yearly growth of 8.9%. In this research the firms in manufacturing increased sales with 8.8% on a yearly basis.

4.3.3 Exports

Export is an important factor to assess the performance of an organisation in foreign markets. Firms were asked to indicate exports as a percentage of total sales (sales ratio). Data is represented for all firms combined, per sector and per size class.

[13] Statistics South Africa. Source:www.statssa.gov.za

Sector	Export ratio 2000 (SAIS 2001/ SAIS 2001 revisited)	Export ratio 2003 (SAIS 2001/ SAIS 2001 revisited)	Export ratio 2003 (StatsSa)
Manufacturing	14.6	15.5	--
Food, beverages & tobacco	40.1	34.9	--
Textiles, clothing & leather products	8.7	10.8	--
Wood and paper (products) & publishing	11.5	8.9	--
Chemicals, rubber and plastic products	8.9	13.0	--
Metal product, machinery, and equipment	14.1	14.2	--
Electrical & optical equipment	23.4	17.2	--
Transport equipment	20.0	17.7	--
Furniture, and n.e.c.	9.2	9.7	--
Wholesale	9.7	4.9	--
Services	8.7	7.7	--
Transport and communication services	16.6	38.3	--
Financial intermediation services	1.6	1.9	--
Business services	10.4	6.7	--
Total	12.9	12.1	8.5

Table 4.10 Export ratio and export growth

In 2000 and 2003 the export ratio of all firms was respectively 12.9% and 12.1%. The CIA fact book shows that the South African industry generated 456.7 billion Dollars GDP in 2003 and an export value of 36.77 billion Dollars. This means an export ratio of 8.05% in 2003 . This is somewhat lower as firms indicated in this research. It is not clear what the reason is for this difference.

The strong Rand influenced the export ratios. In 2002 the value of the rand was R10.5407 per US Dollar and in 2003 R7.5648 per US Dollar. Many export oriented firms complained about this phenomenon.

5 Main characteristics

In this chapter innovation and employment growth in South African firms is described. This is done in three different categories. It will be reflected in different sectors (paragraph 5.1), on firm size (paragraph 5.2) and different regions (paragraph 5.3). The different sectors and regions are similar to what is reflected in chapter two. The four firm-sizes categories are those with less than 50 employees, between 50 and 250 employees, between 250 and 500 employees or more than 500 employees.

5.1 Sectorial distribution

In this paragraph the percentages of innovative firms and the employment growth in each of the 12 sectors is given. The percentages are summarized under firms from the "manufacturing sector" and the "service sector" as well. The eight manufacturing firms are captured under "manufacturing sector" and the three service firms are, together with wholesale, captured under "service sector". In the rest of the report, the sectors are only separated as manufacturing or service sectors. The firms that are taken into account all have more than 10 employees and an employment growth over the period of 2000-2003 between –100 and +100 percent.

5.1.1 Product innovation

The figure below shows what percentage of all the firms had product innovation in the period of 1998-2000.

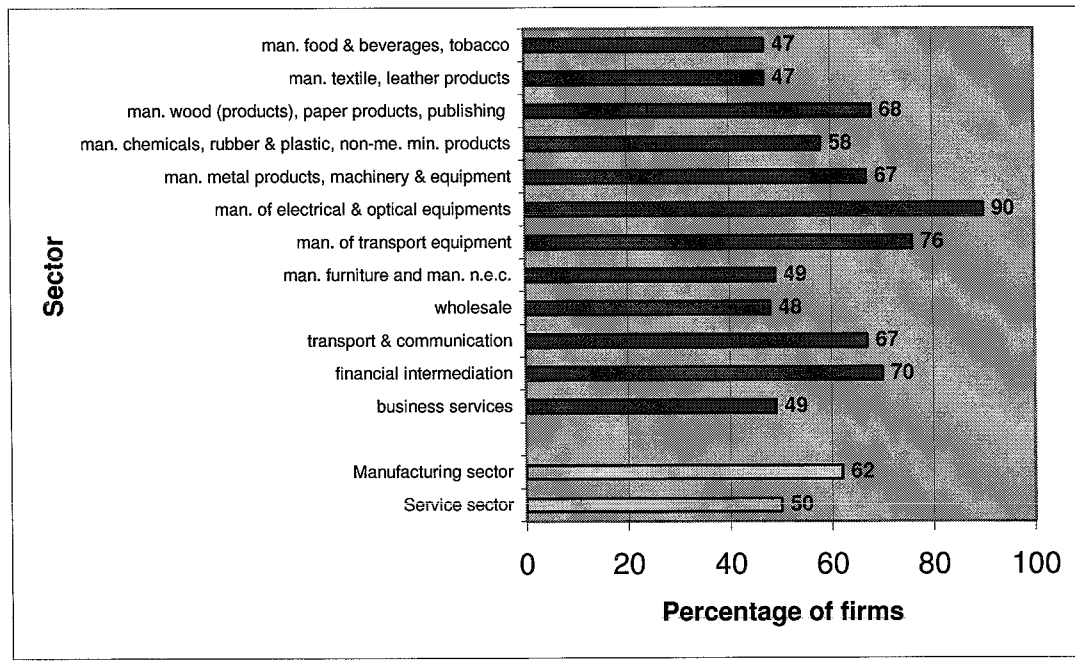


Figure 5.1 Percentage of firms that had product innovation in the period of 1998-2000, classified by sector

In the manufacturing sector 62 percent of the firms indicated they had product innovations over the period 1998-2000. In the service sector this percentage was 50

percent. It seems that the service sector is less product innovative than the manufacturing sector.

5.1.2 Process innovation

Figure 5.2 shows what percentage of all the firms had process innovation in the period 1998-2000 separated within the different sectors.

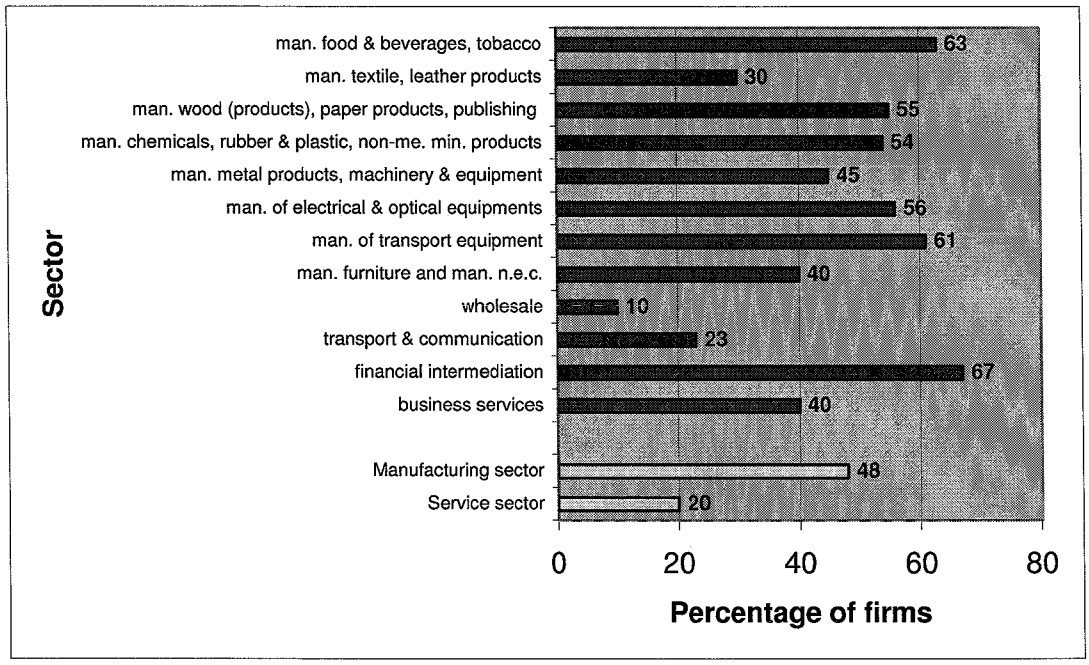


Figure 5.2 Percentage of firms that had process innovation in the period of 1998-2000, classified by sector

In the manufacturing sector 48 percent of the firms indicated they had process innovations over the period 1998-2000. In the service sector this percentage was 20 percent. These numbers are lower than the numbers of product innovation. Firms indicated to be less process innovative than product innovative. Again, the service sector is less process innovative than the manufacturing sector.

5.1.3 Employment growth

In the following graph it is shown per sector what percentage of employment growth took place in each sector over the period of 2000-2003.

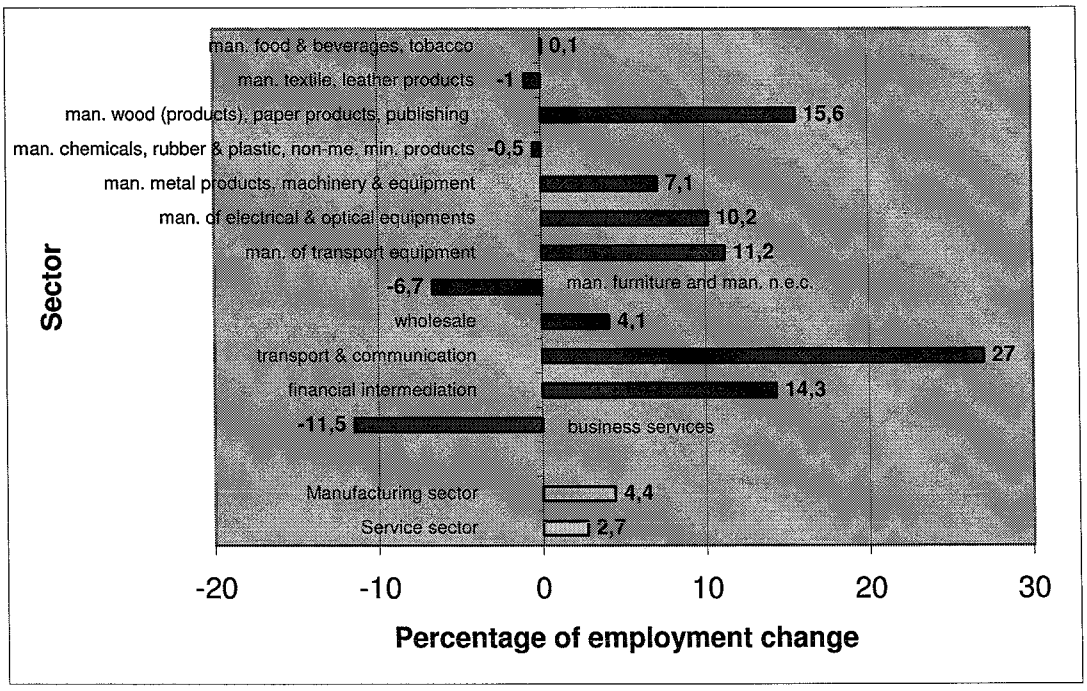


Figure 5.3 Employment growth over the period of 2000-2003, classified by sector

In the manufacturing as well as the service sector there was employment growth in the period of 2000-2003. In the manufacturing sector the employment growth was bigger than in the service sector, respectively 4,4 and 2,7 percent. The mean employment growth in all South African firms is 1.2% a year. This is already stated in paragraph 4.3.1. Four sectors indicated to have a negative employment growth, which is an employment reduction. These sectors are manufacturers of textiles, clothing and leather products, manufacturers of fuel, chemicals, rubber, plastic and other non-metallic mineral products, manufacturers of furniture, manufacturing n.e.c., and recycling and business services.

5.2 Size class

As previously stated in paragraph 2.4, firm size seems to be of influence on innovation and job creation. Bommer and Jalajas (2004) stated that SMEs have more innovative behaviour because of their ability to react more quickly to changing business environment, having greater internal flexibility, are more willing to take risks, being more efficient and having informal communication coupled with less bureaucracy. These advantages make the SMEs more innovative than large firms and explain why SMEs are stated as employment boosters. In this paragraph the relationship between firm size and innovation is displayed. Firms are separated into four groups, firms with:

- Firms with 50 or less employees
- Firms with 51 to 250 employees
- Firms with 251 to 500 employees
- Firms with more than 500 employees

Most of the firms that cooperated with the SAIS 2001 are in the size-category 51 to 250 employees with a contribution percentage of 40 percent. The least representation is from the category 251-500. Only 10 percent of the firms belong to this category. The percentage of firms in these groups that had innovations is presented in Figure 5.4 and Figure 5.5. In these figures manufacturing and service firms are initially shown apart and after that the mean percentage of all firms is displayed. The percentage of product innovators is shown in Figure 5.4 and for process innovation in Figure 5.5.

5.2.1 Product innovation

The figure below shows what percentage of all the firms had product innovation in the period of 1998-2000.

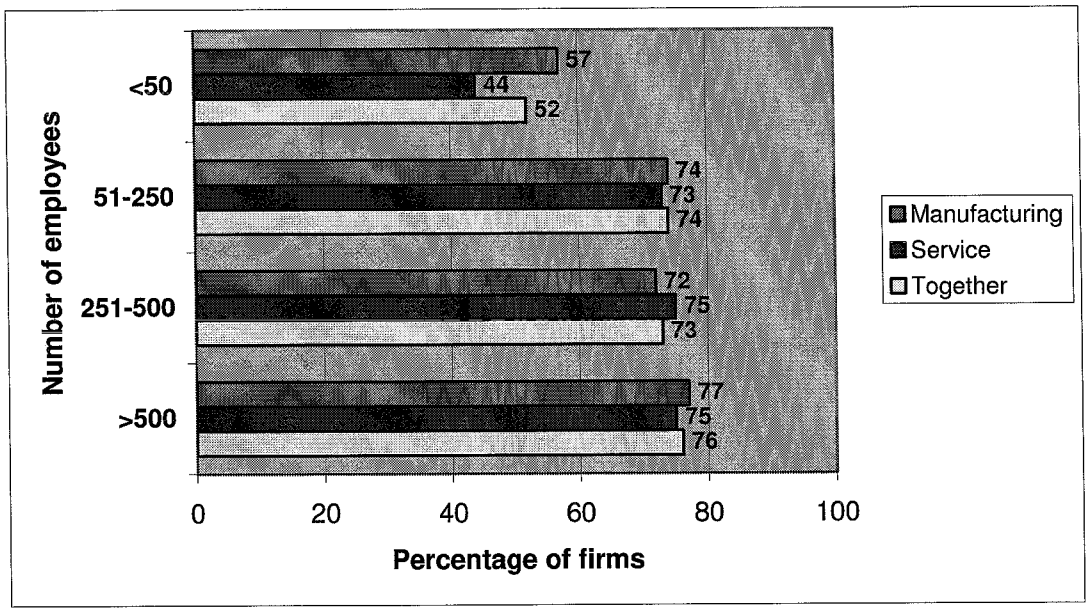


Figure 5.4 Percentage of firms that had product innovation in the period of 1998-2000, classified by firm size

This figure shows that bigger firms innovate more than the smaller firms. 52 percent of the firms with less than 50 employees indicate that they had product innovations over the period of 1998-2000. The rest of the firms indicate an innovativeness that lies around the 75th percentile.

5.2.2 Process innovation

Figure 5.5 shows what percentage of all the firms had process innovation in the period from 1998-2000 categorized by firm size. It is clear that the same shape is visible as in the former graph.

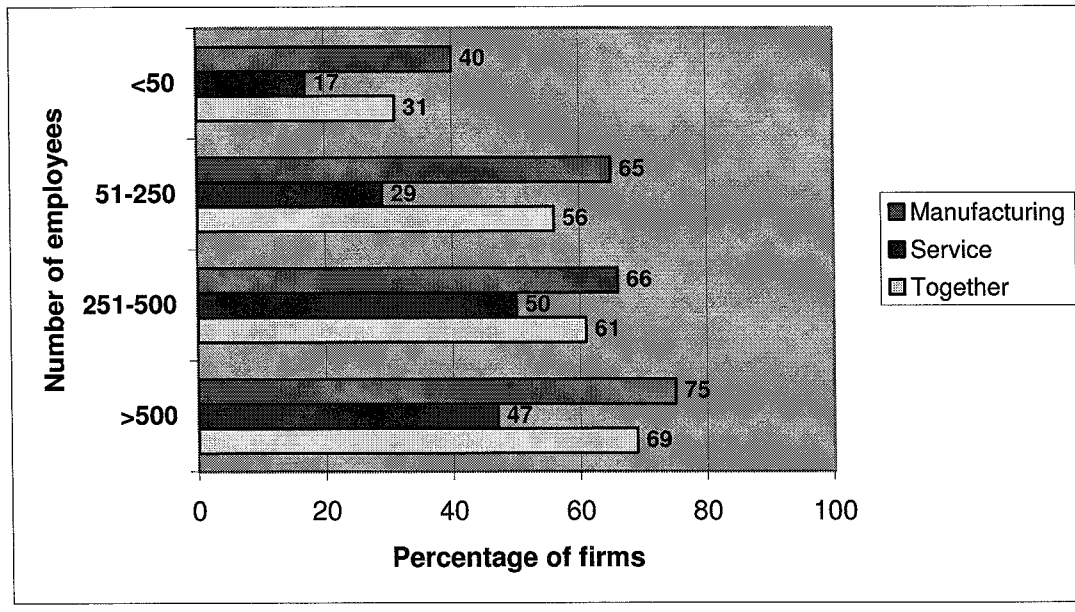


Figure 5.5 Percentage of firms that had process innovation in the period of 1998-2000, classified by firm size

It is obvious that the percentage of innovating firms is higher when firms have more employees. Product as well as process innovation show the same results. This does not mean that, as seen in absolute numbers, the large firms bring more innovations to the market than smaller firms. Although the percentage of innovative firms is lower with the small firms, there are a lot more small firms than large firms in South Africa.

5.2.3 Employment growth

The percentage of employment change in the different firm size categories are presented in Figure 5.6.

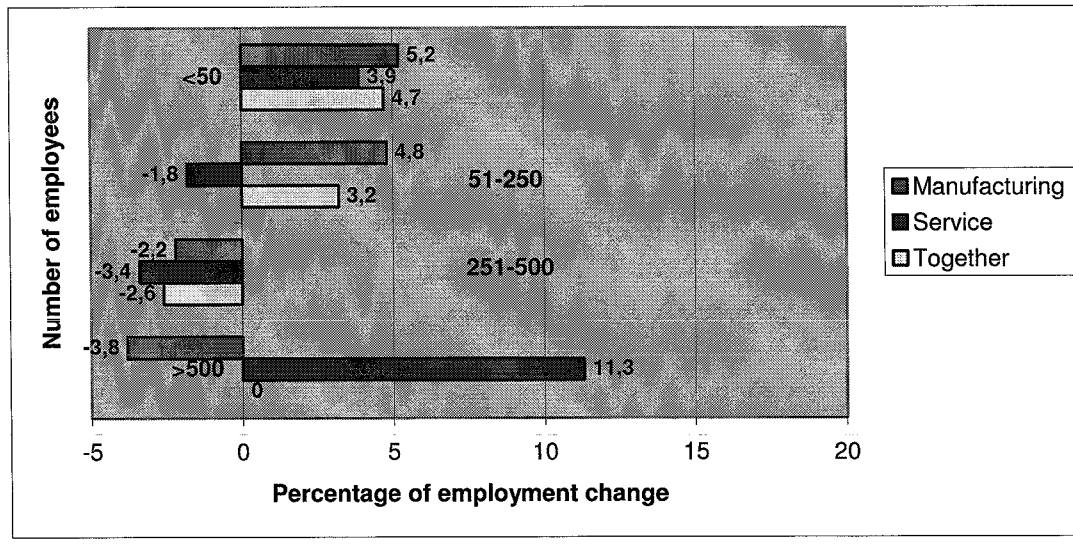


Figure 5.6 Employment growth over the period of 2000-2003, classified by firm size

The highest relative employment growth was in the smaller firms, the firms with less than 50 employees. The figure shows that the bigger the firms become, the less employment growth they have. Firms with more than 500 employees in the manufacturing sector show a decline of employment of 3,8 percent. Firms in the service sector with more than 500 employees had the biggest employment growth of 11.3 percent. The mean employment growth in this category of firms is zero percent.

5.3 Regions

In paragraph 3.3.3 it is explained that South Africa is divided into five regions. In this paragraph it is described what percentage of the product and process innovations is originating from the different regions and where the highest employment growth took place. The regions that South Africa is divided into according to chapter two are:

- Gauteng
- Western Cape
- Kwazulu-Natal
- Eastern Cape
- Remaining provinces (Freestate, Northern Cape, Mapumlanga,Limpopo, North West province

A graph of these regions is displayed in Figure 5.7.

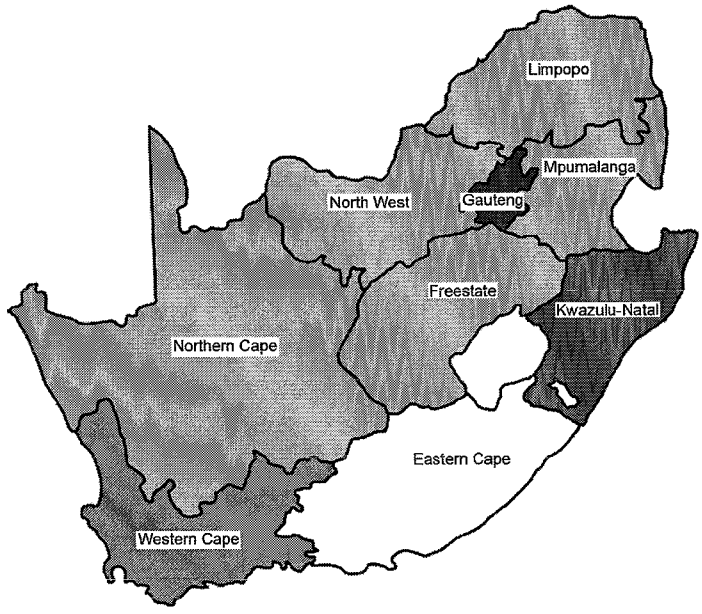


Figure 5.7 The regions of South Africa

Löfsten and Lindelöf (2001) tried to find the added value of Science Parks on new technology-based firms (NTBFs) in the Swedish industry. The key principle of Science Parks is assessing academic knowledge end expertise by business on-site. In the next figure is shown where the 21 universities of South Africa are located[14].

[14] http://www.studysa.co.za/map.htm

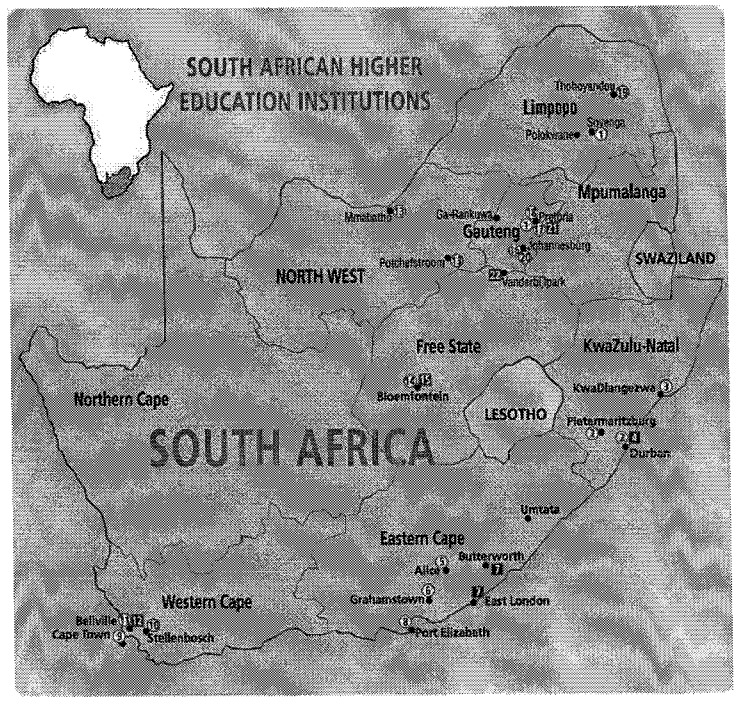


Figure 5.8 South African higher education institutes.

Figure 5.8 shows that in the Gauteng province the most universities are clustered. For firms in this province, it is easier to maintain links with academic knowledge. The research links can exist from formal contracts to informal contacts. Therefore it is assumed that firms in this region are the most innovative. The next figure tells what percentage of firms that cooperated in the SAIS researches are from the different regions.

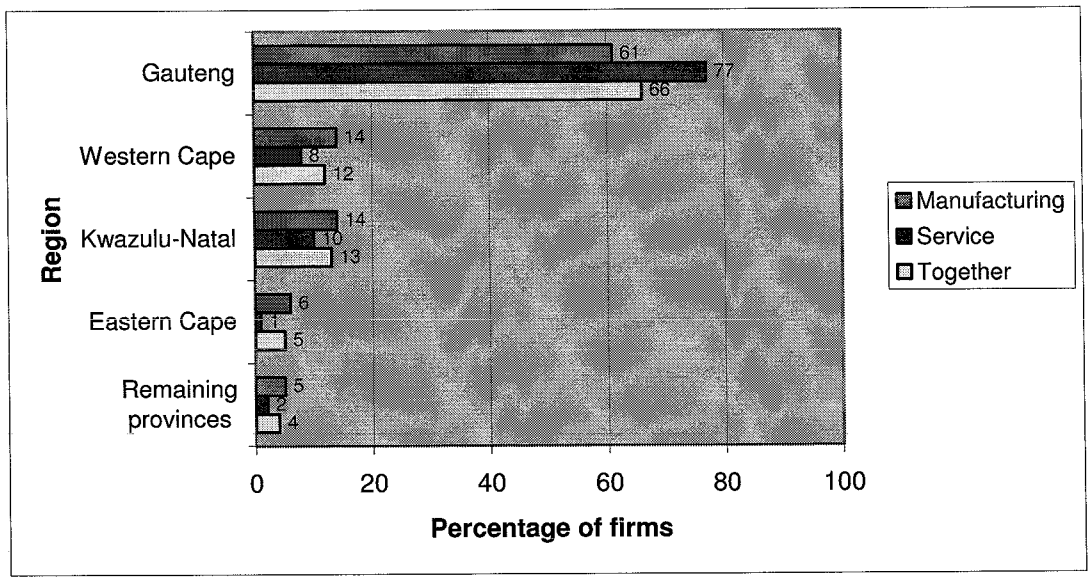


Figure 5.9 Regional distribution

The most firms operate in the Gauteng region. This is not surprisingly since Gauteng is the biggest industrial region with Johannesburg and Pretoria as its industry centres. Cape Town is the biggest industrial centre in Western Cape and Durban plays this role in Kwazulu-Natal.

5.3.1 Product Innovation

In the next figure it is shown what percentage of firms had product innovations in the different regions.

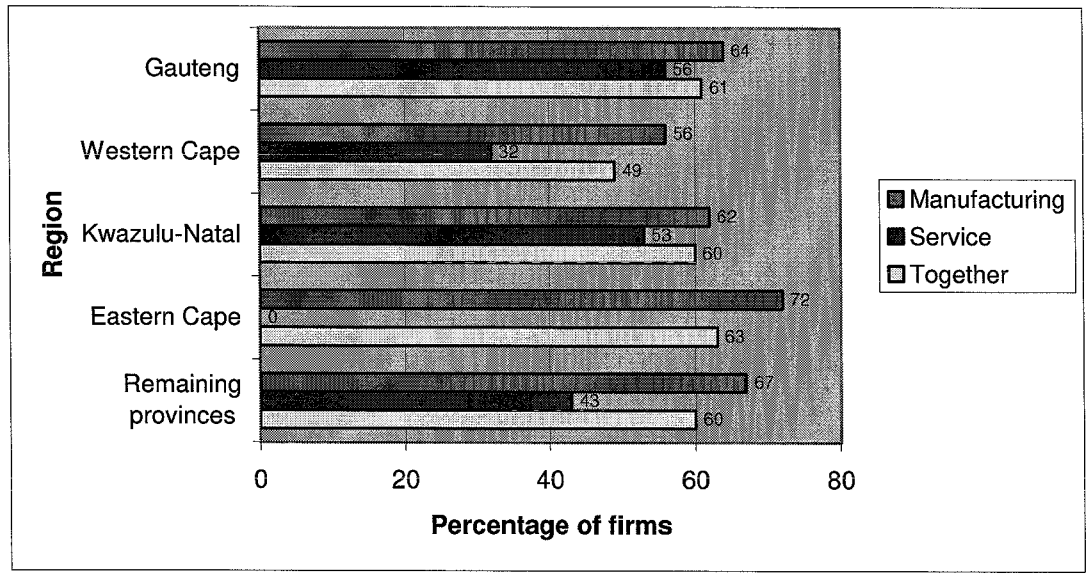


Figure 5.10 Percentage of firms that had product innovation in the period of 1998-2000, classified by regions

In the Western Cape only 49 percent of all the firms indicated they had product innovations. In the 4 other regions the percentages lie close to each other. It can be stated that no real difference can be found between the regions.

5.3.2 Process innovation

Figure 5.11 presents what percentage of firms indicated they had process innovations in the different regions.

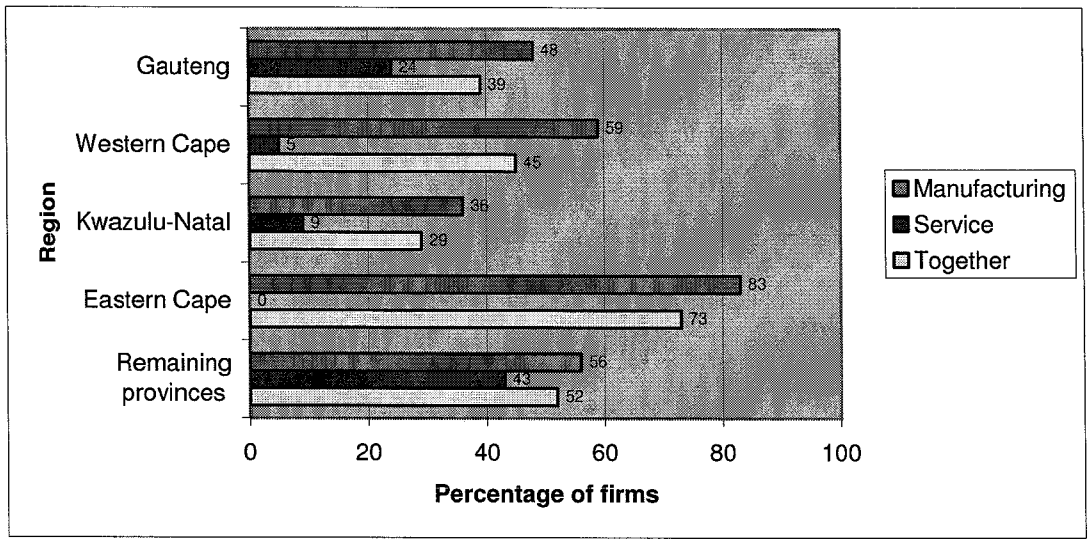


Figure 5.11 Percentage of firms that had process innovation in the period of 1998-2000, classified by firm size

The graph above shows that the percentages of process innovative firms differ a lot. The highest percentages of process innovative firms come from the Eastern Cape. The lowest number is from Kwazulu Natal.

5.3.3 Employment growth

In Figure 5.12 is the percentage of employment growth shown per region.

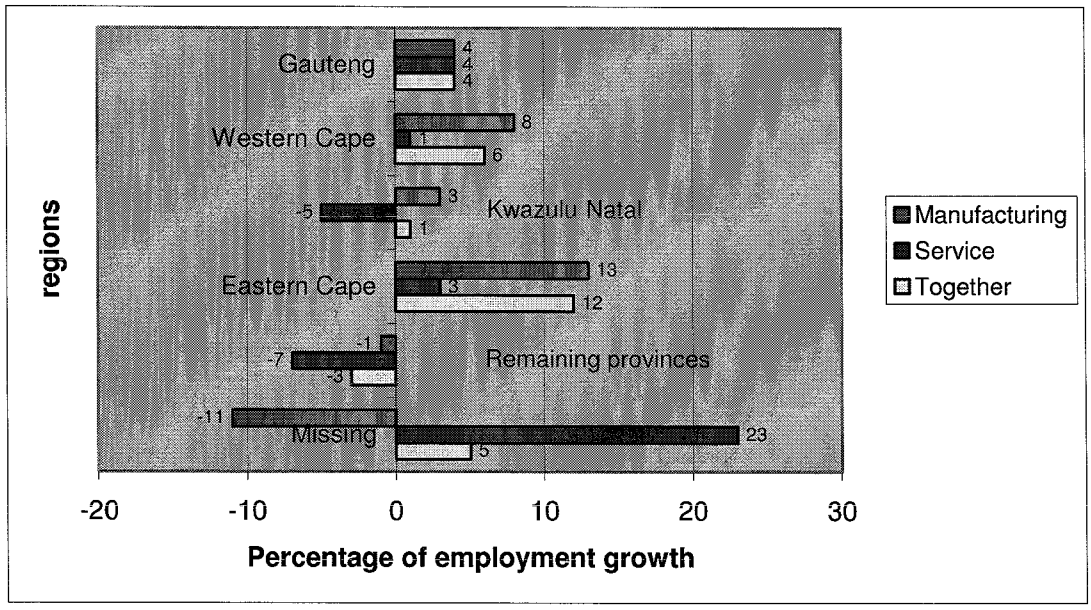


Figure 5.12 Employment growth over the period of 2000-2003, classified by regions

All regions show an increase in employment with the exception of the "remaining provinces" Remaining provinces indicates a decline of three percent. In this graph a category "missing" is taken into account. A couple of firms did not indicate in which region they are active. These firms, from which is not known where they operate,

6 Empirical Analysis

In this chapter the statistical method is described. In paragraph 6.2 it is explained which method is used to examine the impact of innovation on employment. The different dummy variables that play a role in the statistical analyses are described in paragraph 6.3. In paragraph 6.4 the regression is described and the coefficients of the independent variables are given. With these findings the hypotheses can be tested. The first paragraph is used to elaborate on the different ways that innovation can be measured.

6.1 Measuring innovation

Due to empirical and conceptual difficulties, innovation formally was seen in a homogenous view. The degree of innovation was described by Research and Development (R&D) expenditures, one of its inputs, or measured by patenting activities, an output of innovation (Pianta, 2004; Piva, 2003). But these measurements are not without criticisms, and therefore doubtfully appropriate.

R&D expenditures do not always have innovations as an outcome. A failed R&D project requires investments with no innovation as a result. In this case R&D expenditures is an incorrect way to indicate innovation. On the other hand, not all innovations are a result of active R&D development. Firms with no new innovation can adopt new products or processes, maybe with incremental improvements and modulation for the new user's needs. This imitation of products and processes will have an effect of an innovation, especially in a new market, industry, or country (Pianta, 2004). R&D is not necessary to innovate.

A patent gives you the right to stop others from making, using or selling your invention. It provides you a short-term monopoly to market your invention or let others use it under agreed terms. Although the advantages of a patent, companies often choose not to document their innovation. Reasons such as the long time it takes to obtain a patent and the high costs involved hamper patent activity. In this case not all the innovations are recognized when patenting activities are taken as the measurement method.

This report uses the innovation activity measured by the South African Innovation Survey 2001 (Oerlemans et al., 2003). In SAIS 2001 innovation is measured directly, not with uncertain variables. The companies have been specifically asked if they had introduced any innovations over a period of two years. This measurement made it possible to differentiate between product and process innovation, and between innovations new to the firm and innovations new to the market.

6.2 Two stage least squares regression analysis

The statistical analysis of effects of innovation on employment is not straightforward. Innovation as such is not an exogenous variable, but is determined by the model as well. For instance firm size is known to affect the innovative output of a firm; additionally firm size may affect employment as well. Hence, innovation acts as a dependent and a independent variable as well. Normal statistical approaches such as OLS regression are not appropriate in this case since parameter estimates are inconsistent, and it is problematic to separate and identify effects of innovation and other independent variables (Pindyck and Rubinfeld, 1991). To solve these estimation problems I follow an econometric approach that was advanced by Verspagen (2004). This is a two stage least squares approach. In the first stage, probit regressions analyses with product, process and new to the market innovation as dependent variables were conducted. The estimation results were used to construct predicted innovation variables, which were subsequently used in the second stage, which was a normal OLS regression.

6.3 Regression variables

The influence of innovation on employment is determined with regression analyses. The dependent variable in the regression analyses is employment growth rate in the firms over the period from 2000-2003. The employment growth is indicated as the percentage of employment change according to the year 2000. This percentage is measured with the formula presented in paragraph 2.1:

$$emp.gr. = \frac{emp.2003 - emp.2000}{emp.2000}$$

The two main independent variables are the predicted product innovation and the predicted process innovation. These predicted variables are determined in the first of the two stage least squares model. These variables are determined with the dummies product and process innovation, and the influence of the following variables:

- the size of the firm
- whether or not the firm is owned by a foreign firm
- the presence of a change in strategic goals (STRAT)
- the introduction of new marketing concepts or designs (MARDES),
- whether or not the firm was reorganized (REORG)
- whether or not new management techniques were introduced (MANAG)
- whether any innovation projects were not started, stopped or seriously delayed

These variables influence the innovation dummies and determine the predicted innovation dummies. In the second stage of the two stage least squares model, the

coefficients of the independent variables are calculated. Not only predicted innovation is taken into account, other variables are expected to influence employment growth as well. This regression analysis is in concordance with the analysis developed by Verspagen (2004). In the regressions, the following independent variables are expected to influence employment growth:

lsiz: The size of the firm displayed by the natural log of the number of employees
forow: Whether or not the firm is owned by a foreign firm
inpcsp: Predicted variable if a firm has introduced process innovation in the period 1998-2000
inpdtp: Predicted variable if a firm has introduced product innovation in the period 1998-2000
inmark: Predicted variable if a firm has introduced product innovation in the period 1998-2000 that was new to the market
starter: Whether the firm started its business in the period 1998-2000

This is done combined with a multi-level analysis. With the analysis two regressions are formulated. In both regressions the variables from above are taken into account. The difference lies in the next two variables:

spdt: Market share of all the firms that introduced a product innovation in the period 1998-2000.
sinm: Market share of all the firms that introduced an innovation in the period 1998-2000 that was new to the market.

In the first regression only the variable 'spdt' is taken into account and 'sinm' is only taken into account in the second regression.

6.4 Regression model

With statistical software programs the two stage least squares method is used in combination with a multilevel analysis. By use of these programs two regression models are formulated.

The first regression is:

$$empl.gr. = \beta_{0i} - 0.043(0.014)lsiz_{ij} - 0.133(0.060)forow_{ij} - 0.103(0.055)inpcsp_{ij} + 0.139(0.053)inpdtp_{ij} - 0.122(0.048)inmarkp_{ij} + 0.170(0.055)starter_{ij} + 0.101(0.155)spdt_{j} + e_{ij}$$

with: $\beta_{0i} = 0.181(0.084)$

The numbers preceeding the independent variables are the calculated coefficients. The numbers between brackets are the standard error of the coefficients. With these numbers the t-value and the 2-sided p-value is determined. The t-value is calculated as follows:

$$tvalue = \frac{coefficients}{Std.error}$$

For all the coefficients the t-value is calculated and represented in Table 6.1. With the t-value it is possible to determine the p-value. The p-value is dependant on the t-value and the degrees of freedom (df). The degrees of freedom are calculated with following algorithm.

$$df = N - 1$$

The total number of firms that are used in the regression is 511, thus the degrees of freedom are 510. With these numbers the p-value can be determined. The p-value is important to determine the significance. When the p-value is smaller than 0.05 it is assumed that the coefficients are significant. The p-value is also presented in Table 6.1.

	Coefficient	**Std error**	**t-value**	**p-value**
Lsiz	-0.043	0.014	-3.07	0.0011
Forow	-0.133	0.060	-2.21	0.0138
inpcsp	-0.103	0.055	-1.87	0.031
inpdtp	0.139	0.053	2.62	0.0045
inmark	-0.122	0.048	2.54	0.0057
starter	0.170	0.055	3.09	0.0011
spdt	0.101	0.155	0.65	0.258
sinm				

Table 6.1 Estimation results for the employment equation with the variable spdt (p-values are based on a 2-sided t-test)

It is clear that with the exception of 'spdt' all variables are significant. In next regression model the variable 'sinm' is taken into account instead of 'spdt'.

$$empl.gr. = \beta_{0i} - 0.045(0.013)lsiz_{ij} - 0.130(0.060)forow_{ij} - 0.093(0.054)inpcsp_{ij} + 0.134(0.055)inpdtp_{ij} - 0.120(0.050)inmarkp_{ij} + 0.172(0.055)starter_{ij} + 0.012(0.193)cinm_j + e_{ij}$$

where: $\beta_{0i} = 0.208(0.084)$

For this regression model the following table is created in the same way as Table 6.1.

	Coefficient	Std error	t-value	p-value
Lsiz	-0.045	0.013	-3.46	0.0003
Forow	-0.130	0.060	-2.17	0.0152
Inpcsp	-0.093	0.054	-1.72	0.043
Inpdtp	0.134	0.055	2.44	0.0075
Inmark	-0.120	0.050	-2.40	0.0084
Starter	0.172	0.055	3.13	0.0009
Spdt				
Sinm	0.012	0.193	0.062	0.4753

Table 6.2 Estimation results for the employment equation with the variable sinm (p-values are based on a 2-sided t-test)

Although the numbers are slightly different than in the former regression model, the same relationships are shown. It can be concluded that two independent variables have a positive impact on innovation in South African firms. These variables are the firms that introduce product innovations and firms who were recently established. Each of the formed hypotheses in paragraph 3.6 will be discussed.

Hypothesis 1: Firms that introduce product innovations create more jobs than firms that do not introduce product innovations.

One of the two variables that has a positive effect on job creation is 'product innovation'. This coefficient is statistically significant since the p-values of both regression models are less than 0,05. The hypothesis as stated is confirmed.

Hypothesis 2: Process innovation does not change the employment demand.

This hypothesis can be rejected. In both regression models it is clear that product innovations in the period from 1998-2000 had a negative effect on employment growth. This is proven significant since the p-value is below 0,05. Thus, process innovation leads to job destruction.

Hypothesis 3: An innovation new to the market has a bigger influence on job creation than an innovation only new to the firm.

This hypothesis is rejected as well. Innovations that were new to the markets are, according to the regression models, relatively negatively correlated with employment growth. A possible explanation for this finding can be given. It is not known if the innovations new to the market meet the market demand. If it does, the market share including the employment demand rises, but in case of no market demand, the market share will not grow or even decline affecting the employment demand in a similar fashion. It is possible that the latter argument counts for the innovations new to the market.

Hypothesis 4: SME's contribute more to employment growth than large enterprises.

According to Figure 5.6 it is true that smaller firms indicate a higher percentage of employment growth than the larger firms. The regression models underpin this as well. The firm size is negative correlated with the percentage of employment growth. The p-values around 0,001 state this significance.

The two stage least squares analysis is done after a multilevel analysis. With this multilevel analysis the effects of innovation on employment was tested on sector level as well. The effects of innovation on sector level could not be stated significant.

7 Conclusions, discussions and recommendations

Unemployment is one of the most socio-economic pressures that face the government. In paragraph 8.1 is examined to what extend innovation can contribute to employment growth. The influence of control variables and dummies is described as well. The conclusions are discussed in paragraph 8.2 and possible explanations are given. Weaknesses and strength of the method and analyses of this research are given in paragraph 8.3 and the recommendations for further research are discussed in paragraph 8.4

7.1 Conclusions

This report has studied effects of innovation on employment growth in South African firms. Innovation influences employment growth in South Africa both in a positive as well as in a negative sense. Product innovation has an encouraging effect on employment growth. Firms that introduced a product innovation in the period 1998-2000 had more employment growth than firms that did not introduced product innovations. A remarkable finding was that product innovations, which were new to the market, conversely indicated an employment decline. The expectation was that innovations new to the market would have a bigger impact on the market, and a larger employment growth in a similar fashion. Although product innovation has a positive effect on employment growth, the empirical analyses shows that South African firms, which introduced process innovations in the period 1998-2000, had an overall employment decline in the period 2000-2003. Thus, process innovations had a negative influence on employment growth. Apparently, the process innovations replace manual labour, but this is not counterbalanced by market mechanisms. The effect of product and process innovation on employment is tested on sector level as well. The relations on firm level could not be found on sector level. It is not known how innovation influences employment on more aggregate level.

Besides innovation, the effects of firm size, firms with a foreign ownership and firms that started in the period of 1998-2000 on employment growth are studied. Firms innovate in an increasing degree when they have more employees. Although it seems that the small firms are less innovative than the larger firms, the employment growth occurs mostly in the smaller firms. The SMEs show the highest relative employment growth. According to the regression models it also seems that firm size has a significant influence on employment growth. Large firms indicate lesser employment growth due to innovation. The SMEs seem to be the employment boosters. The negative correlation between firm size and employment growth is found for firms with a foreign owner as well. The firms with a foreign owner indicated to suffer from job losses. Starters in the period 1998-2000 had an employment growth. This could be in relation with the firm size. Starters are part of the category small firms with few employees.

The results of this research are compared with a research done by Verspagen 2004). Verspagen (2004) has researched the effects of innovation on employment in Dutch firms. He used the data from CIS II, the survey on which the SAIS 2001 is based. This ensures that the datasets used in both researches are analogous. The analysis as done in this report is based on the analysis done in his research as well, and therefore it is credible to compare both researches. Comparing the researches, some remarkable contradictions attract the attention. In South Africa the correlation between process innovation and employment growth is negatively correlated. The results of Verspagen (2004) showed a positive, but not significant relation. It is not clear why these differences occur. For innovations that are new to the market, and firms that have a foreign ownership, a negative correlation was found in this research. The finding that these factors had an employment decline is the opposite of the expectation that was created by Verspagen (2004). The following discussion enlarges about these differences.

7.2 Discussion

The effect of process innovations on employment growth in South African firms is negatively correlated. Process innovation is a labour saving innovation. Manual labour is replaced by automation and the market mechanisms do not compensate the job losses. Possible explanations for this outcome can be found in the fact that South Africa is a developing country were wages are relatively low. Since the wages are relatively low, the cost price reduction that goes accompanied with the introduction of automation is also relatively small. Therefore the market demand will not change and the growth of market share fails to occur. In this case process innovation directly leads to job destruction and no jobs are gained due to production growth.

Another remarkable finding is the negative impact of innovations, that were new to the market, on the employment demand. The assumption was that radical innovations had a stronger positive impact on employment than an innovation only new to the firm. This assumption is underpinned in the research of Verspagen (2004). There is a large discrepancy between the results of the two researches. This could be the result of different qualities of innovations. If the innovations new to the market do not suit the question of the market, the innovation is not launched successfully. Since South African industry is claimed to have the follower status in technological development, it is possible that the quality of innovations is less developed. In this case, the expected employment growth due to innovations new to the market, is undeserved; the introduction of the innovation could even have the opposite effect. Another explanation lies in the maturity of the South African market. If the European market is more open for innovations, it is easier to sell new products. The new product needs a good marketing as well. If the innovation goes without good marketing it is hard to launch the new product successfully.

Several firms indicated to have a foreign owner. The firms that had their head office in another country suffered from overall job loss in the period of 2000-2003. If the

relevant firms were mainly active in manual production, it could be possible that the activities are shifted to other low wage countries. Firms with foreign owners could shift to other low wage countries, but another possibility lies in the replacement of manual labour by machinery. In this case a link between the conclusions of the effects of foreign ownership and process innovations on employment growth can be drawn.

The firms that started their business in the period 1998-2000 showed a positive correlation with employment growth. However, there is no information available about firms that were started in this period and did not survive. As a result, these firms that did not survive, are not taken into account with the statistical analysis. In this case, the positive correlation between this factor and employment growth could be overestimated. Another comment that has to be made is that firms started in the period of 1998-2000 are the so-called small firms. A relation between the conclusions of the effects of firm size and started in the period of 1998-2000 is presumably.

Although it is stated that the research of Verspagen (2004) could be compared with this research, three comments have to be placed. The research of Verspagen (2004) was based on a dataset with more than 3000 cooperating firms. A bigger dataset could have stronger conclusions as a result since the standard deviation is inversely proportional with the square root of the number of observations. Therefore his conclusions could be more reliable. On the other hand, the data of the research at hand is of a longitudinal design and the data used by Verspagen (2004) of a cross sectional design. In contrast with a longitudinal design, a cross sectional design measures at one point in time variables over a time span. Therefore an appeal on one's memory is done what results in less reliable data. Another important comment that has to be made is that a cross sectional research measures the impact of the independent variable on the dependant variable over the same time-span. The effects of innovation in a period of time, is examined on employment over the same period. This is dubious since the effects of innovation appear to come up after one or two years. A longitudinal approach like used in this research avoids inconsistencies as stated above.

7.3 Weaknesses and strengths

In this research a unique longitudinal dataset is used. The firms that cooperated in the year 2000 were interviewed in 2003 for the second time. Numerous researches on the innovation and employment topic have been conducted in Europe and America. The used data in these researches was mostly of a cross sectional design. With the longitudinal method less bias is present and the numbers are more accurate than with the cross sectional design method.

The data collection of SAIS 2001 revisited was mostly done with a telephonic interview. This made it possible to obtain new data over the year 2003 and verify the

data of the year 2000. Via this check wrong answers were filtered. It is a laborious method but led to trustworthy data and increases the reliability of a research like this.

During the data verification it was clear that 16 firms could not be traced anymore. 32 other firms were merged or went out of business. These companies could not be contacted for the second cooperation and are not taken into account with the analysis. However, it's likely that the firms that went out of business have to be taken into account within the analysis since this accompanies job destruction. Since the distinction between firms that went out of business, merged or changed names could not be made, these firms are not part of the analysis. This could cast a cloud upon the results of the analysis.

The analysis in this research had several control variables. These control variables were taken into account to conclude that the independent variable is responsible for variation in the dependent variable. Although different control variables show to have an impact on employment, it is proven that innovation has a significant effect on employment. However, the data has some weak aspects. The questions asked to the firms about innovation can be interpreted in different ways. Although an interpretation of innovation is given in the SAIS 2001 questionnaire, it's still an abstract notion.

The time period between the introduction of innovations and its effect on employment is important for the internal validity as well. If the time period is too short, the effects of innovation on employment are not present yet. If the time period is too long, the effects could fade away. The time lag between the measurement of innovation and the measured employment growth is a period of three years. According to literature the time lag has to be at least one or three years. Therefore it is stated that the effects of innovation are present.

The SAIS 2001 dataset was representative for the South African industry. After a non-response survey this could be concluded. This dataset was complemented with data over the year 2003 obtained with SAIS 2001 revisited. To get a representative longitudinal dataset the response rate of SAIS 2001 revisited had to be high. The response rate of the SAIS 2001 revisited turned out to be 97.7 percent. This high response rate of the representative cooperating firms allows stating that the findings represent the South African industry.

7.4 Further research

The first recommendation for further research is about innovation and employment growth on sector level. The business stealing effect can assure that the jobs gained with the innovative firm are lost at the non-innovative firm. In this certain case the overall employment could fail to appear. The research from Verspagen (2004) has indicated that the effects of innovation on employment also hold at a more aggregate level. In that research a dataset of 3039 firms is used. This dataset is larger than the dataset used in this research. Therefore a bigger chance on significance is available.

The statistical analysis in this report is complemented with the multilevel analysis to indicate sectorial influences. The first recommendation is to check the results of both researches with the analysis used in this research on the dataset of Verspagen (2004).

Further research can give more insight into the effects of innovation on employment. Another recommendation is about firms that merged or firms that went out of business. The data of these firms are not taken into account with the statistical analysis but could have an impact on the results of the research. It's recommended that this impact should be studied.

Product innovation new to the market seems to have a negative effect on employment growth. This outcome contradicts the expectations. A possible explanation can be found in the fact that the new innovations were not launched successfully into the market. New data about this topic could give more trustworthy information over the effects on employment.

The measurement as done in this research is a one-moment overview. If a research like this gets a repetitive character, for example on a yearly base, trends could be better described an a better overview of the impact of innovation on employment is provided. Causalities are proven with more certainty and conclusions are more reliable.

Firms with a foreign owner indicated to have an employment decline. This is in conflict with the results of Verspagen (2004), who found a positive relation between these variables. Further research on foreign cooperation is necessary to explain these findings.

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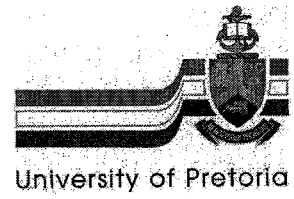
Appendix ACovering letter



**Faculty of Engineering,
The Built Environment and
Information Technology**

**Department of Engineering
and Technology Management**

7 September 2004

Dear Sir/Madam,

The Department of Engineering and Technology Management at the University of Pretoria conducted a national survey on innovation in the manufacturing and services section in South Africa. Your company contributed to the success of this survey in 2001. The full survey report was handed over to the Minister of Science and Technology in the beginning of 2004 and is also available at www.sais2001.up.ac.za.

We are currently conducting a short follow-up on the SAIS 2001 survey. Our purpose is to discover to what extent innovation has contributed to economic development and employment growth in South Africa over the last few years.

For this reason we have developed a short questionnaire to gather imperative, longitudinal information on innovative performance, survival, sales and exports. Because of your cooperation a few years ago, your response is exceptionally valuable. We kindly ask you to complete this questionnaire. It will only take five minutes of your time. We would really appreciate your time to help us with this important matter.

Regards,

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Appendix B Survey

survey number

Faculty of Engineering,
The Built Environment and
Information Technology

Department of Engineering
And Technology Management

Head of department: Professor M.W. Pretorius

South African Innovation Survey: SAIS2004

The purpose of this survey is to measure innovative performance, employment, sales and exports of South African firms. The data collected will be compared with data from the SAIS 2001 survey, which was handed to Dr. Ben Ngubane, who was the Minister of Science and Technology at the time.
With these data we want to measure the influence of innovation on employment, survival and alliances.

The ten questions should only take a few minutes of your time. All information will be handled confidentially!

Instructions:

Please fill out Yes/No questions as follows:

Yes ☐
No ☒

Questions that require a figure can be indicated as follows:

25%

After completion, please return the Questionnaire to:

Contact person: Anthea van Zyl
Fax: (012) 362 5092
E-mail: SAIS2004@up.ac.za
Tel. No.: (012) 420 3843

General information:

Name of company : .....

Name respondent : .....

Physical Address : .....

Telephone number : .....

E-mail address : .....

Employment:
Q1a: "What were the number of employees in your firm in 2003?"

Employees 2003: .....

Q1b: "Has there been an increase or decrease of employment in the last 3 years?"

No, unchanged ☐ ➔ Please, go to Q2
Yes ☐ ➔ Increase ☐
Decrease ☐

Q1c: "Did this employment change occur at all education levels in your firm? (Please distinguish between lower education, medium education and higher education-level jobs?)"

Yes ☐
No ☐ ➔ mainly at: Lower education/Operator level ☐
Medium education/Supervisory level ☐
Higher education/Management ☐

Comments? .....

.....

.....

Innovative product/services:
Q2a: "Did your firm introduce any technologically new or improved products or services during 2003?"

Yes ☐
No ☐ ➔ Please, go to Q3

Q2b: "Were these "step-by-step" changes or "drastic changes" in your product or services?"

Step-by-step changes ☐
Drastic changes ☐

Q2c: "What sales percentage were contributed by these step-by-step and drastically changes products or services during 2003?"

Sales percentage from step-by-step product/services: ..... %

Sales percentage from drastically products/services: ..... %

Q2d: "Were these products new to the market or was it a modification of an already existing idea?"

New to the market ☐
Existing idea ☐

Comments? .....

.....

.....

Innovation processes:
Q3: "Did your firm introduce any technologically new or improved production processes in 2003?"

Yes ☐
No ☐

Comments? .....

.....

.....

Sales:
Q4: "What were the total sales in 2003?"

Total sales 2003: ..... Rand

"If you don't have the figures off-hand, would you say there was an increase or a decrease in sales in comparison with the year 2000? Could you indicate this as a percentage?"

No, unchanged ☐

Increase ☐ Percentage: .....%

Decrease ☐ Percentage: .....%

Comments? .....

.....

.....

Exports:
Q5: "What were the exports as a percentage of total sales in 2003?"

Export as a % total sales 2003: ..... %

"If you don't have the figures off-hand would, you say there was an increase or decrease in exports in comparison with the year 2000? Could you indicate this as an percentage?"

No, unchanged ☐

Increase ☐ Percentage: ..... %

Decrease ☐ Percentage: ..... %

Comments? .....

.....

.....

Any other general comments you would like to make?

.....

.....

.....

.....

Thank you for your cooperation!

Contact information SAIS2004 project:
Contact person: Anthea van Zyl
E-mail: SAIS2004@up.ac.za
Tel.: (012) 420 3843
Fax: (012) 362 5092