

**Innovation and Knowledge Flows
in the South African Manufacturing Industry:
Econometric Evidence from
the National Innovation Survey**

Extended Abstract

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Introduction

In this paper we present empirical results on the impact of knowledge generation and knowledge flows on product and process innovation in the South African manufacturing and mining sectors. We are investigating firm level data from the first official South African National Innovation Survey 2005 comparable to the Fourth European Community Innovation Surveys (CIS 4). It is the first econometric study on innovation behaviour in a Sub-Saharan African country using CIS 4 type data sources.

Data

After two previous unofficial surveys in 1994 and 2000, the first official South African National Innovation Survey was carried out by the Centre for Science, Technology and Innovation Indicators (CeSTII) at the Human Sciences Research Council (HSRC) of South Africa in the year 2005. The survey was based on a stratified random sample of 3087 enterprises provided by Statistics South Africa from the official business register. The field work contained a postal survey with telephonic and written follow-ups as well as a non-response survey (DST, 2007). The overall response rate of 32% led to a net sample of 979 firms in manufacturing, mining and selected service sectors. The survey provides information on the extent of innovative activity and various other measures characterizing knowledge flows like co-operation partnerships and sources of information on innovation (Blankley, 2007, and Blankley et al., 2007).

The methodology of the survey is based on the OECD recommendations on innovation surveys documented in the Oslo manual (OECD, 2005). It is directly comparable to the CIS 4 coordinated by the Statistical Office of the European Communities (Eurostat) and undertaken in all countries of the European Union (EU) and a large number of other European and Non-European countries (Parvan, 2007a and 2007b). The survey questionnaire uses the same definitions of innovation and innovative activity and is based on the CIS 4 core questionnaire with some minor adjustments to the situation of the South African society and economy (HSRC, 2005)

We concentrate our analysis on the South African manufacturing and mining sectors. After adjusting the sample for item non-response to questions we are particularly interested in, a sample of 360 firms forms the basis for our empirical analysis. The structure of the sample is contained in table 1. The industry classification follows the South African Industry Classification (SIC) on a 2-digit level. 32 mining firms and 328 manufacturing firms are included in our sample. The largest sub-samples are formed by the sector producing coke, refined fuel and nuclear fuel (61 firms), the food, beverages and tobacco industry (51 firms) and the metal industry (49 firms).

Table 1 includes basic information on innovation activities of firms in our sample.¹ 221 firms have introduced products to the market in the period 2002 to 2004, which were new or significantly improved to the firm. These firms are classified as product innovators. In 164 cases these products included innovations new to the market (market novelties). 215 firms introduced methods of production, logistics, delivery, distribution or supporting activities which were new or significantly improved to the firm. They were classified as process innovators.

In this paper we are aiming to explain firms' propensity to be innovative depending on their activities of knowledge generation, knowledge sourcing and knowledge sharing, but controlling for structural differences between firms.

Empirical Methodology

To identify relevant explanatory factors, we estimate three separate equations: one for product innovation, one for market novelties and one for process innovation (according to table 1). The discrete nature of the dependent variable is taken into account by applying a discrete binary choice model: the Probit model (see e.g. Maddala, 1983).

We summarize possible explanatory variables in four groups: knowledge generating activities, external acquisition of knowledge on the market, knowledge sharing through co-operation and informal knowledge sourcing through sources of information. Table 2 summarizes these variables as well as variables characterizing firm structure and offers basic descriptive statistics. Other variables belonging to these groups have been tested empirically, but were not contained in the tables and final specifications if they were not statistically significant.

Firm structure is captured by three variables: Firm size measured as the natural logarithm of the number of employees, skill structure measured by the share of qualified personnel with a tertiary degree and industry classification measured by a sector dummy variable. We concentrate on three dummies for industries or groups of industries which are likely to behave different to other industries: the mining industry (SIC 21-29), the electric industry (SIC 36, 37) and the automotive industry (SIC 39).

Knowledge generation comprises internal knowledge generation and external knowledge sourcing. Internally knowledge can be generated through R&D activities which can be either occasional or continuously or through training of personnel. Therefore, we include three dummies in our estimation equations: one for R&D, one for continuous R&D conditioning on R&D and another for training activities related to innovation projects. External knowledge can be either embodied in machinery and equipment or disembodied. Therefore, both activities acquisition of machinery, equipment and software as well as acquisition of other external knowledge (like patents, licences, know-how) are included as dummy indicator variables.

¹ These results are non-weighted and not extrapolated to the population of South African firms. They do not represent the South African Economy. Shares calculated may and in most cases will differ from the official publications. For the latter see Blankley, 2007, and Blankley et al., 2007.

There is a wide literature on the effects of co-operation using CIS data in Europe (e.g. Belderbos et al. 2004). The motives for innovation co-operation are mainly generating knowledge inflows and prohibiting knowledge outflows (Cassiman and Veugelers, 2002). This is a special case of knowledge sharing, i.e. active participation with other enterprises or institutions on innovation have two dimensions: type and region (Monjon and Waelbroeck, 2002). We split the complex co-operation questions in these dimension and generate a group of dummy variables: co-operation with customers, co-operation with consultants, commercial labs or private R&D institutes regardless which region the partners do come from, co-operation with US-American companies, co-operation with Asian companies and co-operation with African (except South African) companies regardless which type of partner and a general dummy indicating co-operation (except other enterprises within a group if existent).

External sourcing of information is partly correlated with co-operation activities. There are always information flows between co-operation partners. Thus, dummies for information sources capture effects beyond co-operation. We include two dummies: information sourcing through conferences, trade fairs, exhibitions and information sourcing from governmental or public research institutions.

Empirical Results

Probit estimates of simple innovation equations regressing on structural properties of the firm are summarized in table 3. In line with the literature (see Cohen, 1995), we find a nonlinear U-shaped relationship to firm size and a positive effect of skill structure on the propensity to innovate. As could be expected mining firms are less likely to innovate when it comes to products, whereas firms from the electric industry are more likely to be innovative. Moreover, firms from the automotive sector are more likely process innovators.

Estimates of the model extended to knowledge generation and knowledge flows a summarized in table 4. Impacts of structural properties remain mainly unchanged. The two main difference are: process innovation is independent of firms size. Moreover, effects of skill structure can only be established for market novelties, not for product and process innovation. But, both variables, firm size and skill structure, do strongly correlate with other explanatory variables, especially with R&D. Thus, their effect is difficult to measure.

As expected, knowledge generating activities play an import role for innovation. The R&D dummy is significant for all three activities. Especially introduction of market novelties is strongly driven by R&D where it is even more important to perform R&D on a continuous base. Training of personnel is significant factor, too.

Acquisition of external knowledge does not increase the propensity to generate market novelties. Both, acquisition of machinery and acquisition of other knowledge increase the propensity to introduce product innovation while process innovations are mainly driven by investing in machinery, equipment and software.

Knowledge sharing through co-operation with other firms or institutions influences innovations in various ways. While co-operation in general favours product innovations, it is only co-operation with customers, i.e. market oriented co-operation (N'Guyen and Owen, 1992) that increase the propensity of market novelties. Firms co-operating with consultants and other private institutions are less likely to introduce market novelties or product innovations in

general. Here, a problem of endogeneity does occur since less innovative and less successful firms may contact and co-operate with consultants. Regional differences in the effects of co-operation on innovativity are remarkable. Firms co-operating with US-American firms are more likely to introduce product innovations or even market novelties while firms co-operating with Asian firms are less innovative on the product markets. For process innovations co-operation does not play an important role. The effect of co-operation within the African continent is negative significant, but only at 10% error level.

Most of the information sources are irrelevant once co-operation is introduced. Only two effects remain: Firms sourcing information on conferences, trade fairs and exhibition are more likely to introduce product innovations or market novelties. Public information sources, i.e. the government or public research institutes, do foster process innovations and product innovations, but not market novelties.

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Table Appendix

Table 1: Sample Composition

Industry (SIC 2)		Total Number	thereof with		
			Market Novelties	Product Innovation	Process Innovation
21	Coal & Lignite	7	2	3	4
22	Crude Petroleum & Gas	3	1	3	2
23	Gold & Uranium Ore	7	1	5	5
24	Other Metal Ores	10	1	1	3
25, 29	Other Mining & Quarrying	5	0	1	2
30	Food, Beverages & Tobac.	51	19	26	26
31	Textiles, Clothing & Leath.	24	12	14	12
32	Wood, Wood/Cork Prod.	33	15	18	19
33	Coke, Ref. Petr. & Nucl. Fuel	61	34	46	43
34	Other Non-Metal. Min. Prod.	20	9	12	11
35	Metal Products	49	20	28	28
36	Electrical Machinery & App.	13	11	13	12
37	Radio, TV, Comm. Equip.	16	11	12	6
38	Transport Equipment	29	12	21	25
39	Furniture, other & Recycl.	27	13	15	15
Total		360	164	221	215

SIC2 = 2-digit South-African Industry Classification.

Non-weighted numbers in estimation sample, not in South African population of firms.

Table 2: Descriptive Statistics

	Overall Mean	thereof with		
		Market Novelties	Product Innovation	Process Innovation
Log Firm Size (# Empl.)	4.67	5.01	4.94	5.11
Share of Qualified Person.	11.41	14.15	13.00	12.51
R&D (D)	0.56	0.82	0.81	0.78
Continuous R&D (D)	0.34	0.56	0.50	0.49
Training (D)	0.57	0.81	0.79	0.81
Acquisition Machinery (D)	0.61	0.84	0.85	0.90
Acquisition Knowledge (D)	0.28	0.38	0.40	0.43
Co-Operation	0.37	0.56	0.55	0.53
Co-Operation Customer	0.31	0.49	0.46	0.44
Co-Operation Consultants	0.21	0.29	0.30	0.31
Co-Operation USA	0.16	0.26	0.24	0.21
Co-Operation Asia	0.09	0.13	0.13	0.13
Co-Operation Africa	0.06	0.08	0.08	0.08
Information Conferences	0.24	0.38	0.36	0.33
Information Public	0.06	0.10	0.10	0.10

Table 3: Probit Estimates of Basic Innovation Equations

	(1) Market Novelties	(2) Product Innovation	(3) Process Innovation
Log Firm Size (# Empl.)	0.758*** (0.194)	0.755*** (0.176)	0.726*** (0.185)
Log Firm Size Squared	-0.054*** (0.018)	-0.054*** (0.017)	-0.045** (0.018)
Mining Industry (D)	-0.698*** (0.250)	-0.376* (0.219)	-0.192 (0.223)
Electric Industry (D)	0.784*** (0.250)	0.903*** (0.297)	
Automotive Industry (D)			0.651** (0.290)
Share of Qualified Person.	0.017*** (0.005)	0.017*** (0.005)	0.014*** (0.005)
Constant	-2.565*** (0.527)	-2.088*** (0.475)	-2.233*** (0.494)
Observations	360	360	360

(D) indicates dummy variables, standard errors in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

**Table 4: Probit Estimates (Marginal Effects)
of Extended Innovation Equations**

	(1) Market Novelties	(2) Product Innovation	(3) Process Innovation
Log Firm Size (# Empl.)	0.152* (0.079)	0.130* (0.069)	0.041 (0.085)
Log Firm Size Squared	-0.013* (0.007)	-0.015** (0.007)	-0.004 (0.008)
Mining Industry (D)	-0.195** (0.093)	-0.108 (0.100)	-0.051 (0.098)
Electric Industry (D)	0.272** (0.122)	0.214*** (0.072)	
Automotive Industry (D)			0.237*** (0.055)
Share of Qualified Person.	0.005* (0.002)		
R&D (D)	0.220*** (0.081)	0.384*** (0.068)	0.195*** (0.073)
Continuous R&D (D)	0.214** (0.084)		
Training (D)	0.231*** (0.067)	0.150* (0.081)	0.240*** (0.079)
Acquisition Machinery (D)		0.231*** (0.076)	0.557*** (0.068)
Acquisition Knowledge (D)		0.130* (0.072)	
Co-Operation (D)		0.251*** (0.097)	
Co-Operation Customer (D)	0.186* (0.096)		
Co-Operation Consult. (D)	-0.176* (0.090)	-0.264* (0.148)	
Co-Operation USA (D)	0.185* (0.104)	0.252*** (0.073)	
Co-Operation Asia (D)	-0.205** (0.100)	-0.265* (0.151)	
Co-Operation Africa (D)			-0.272* (0.153)
Information Conferences (D)	0.173** (0.077)	0.211*** (0.063)	
Information Public (D)		0.231*** (0.083)	0.370*** (0.067)
Number of Observations	360	360	360

(D) indicates dummy variables, robust standard errors in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%