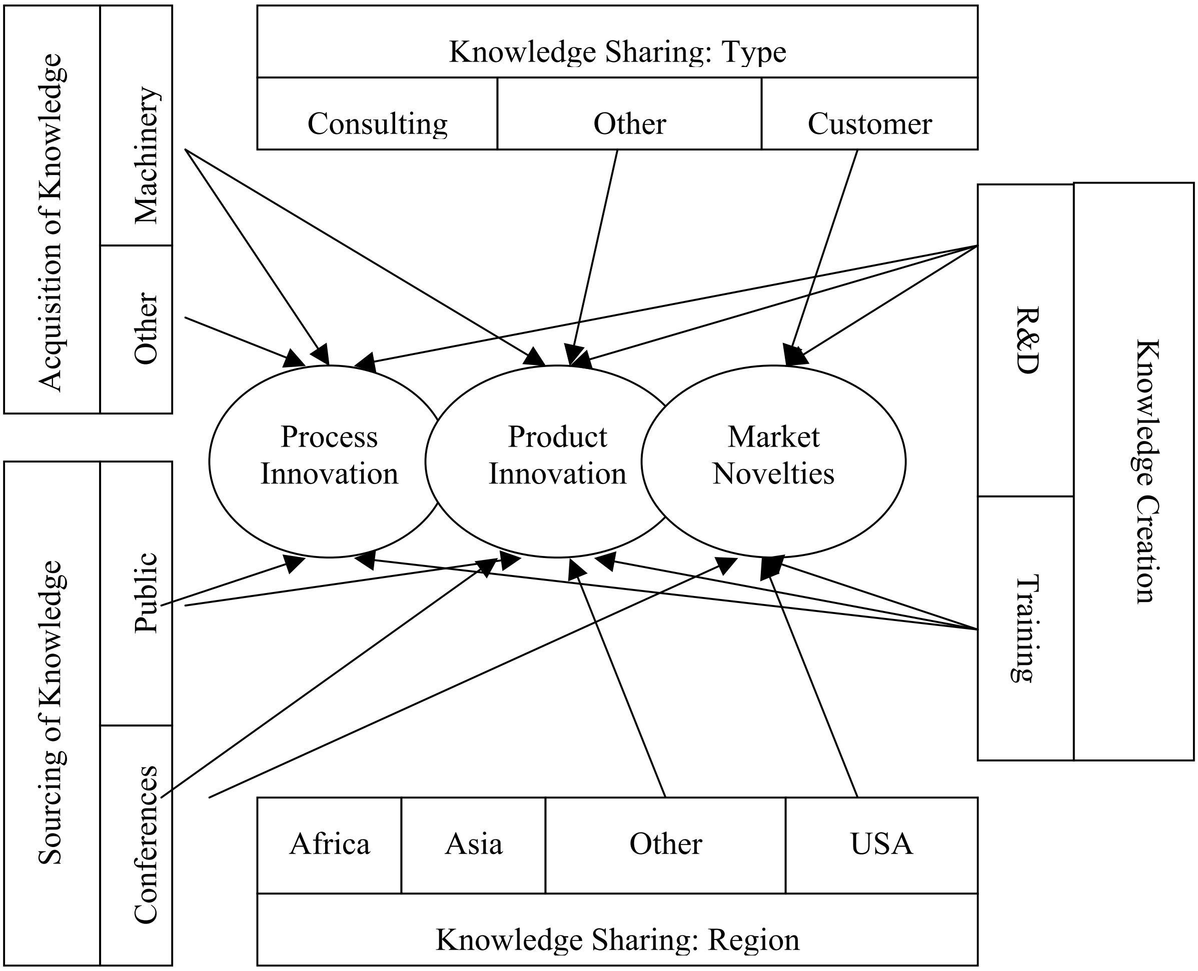
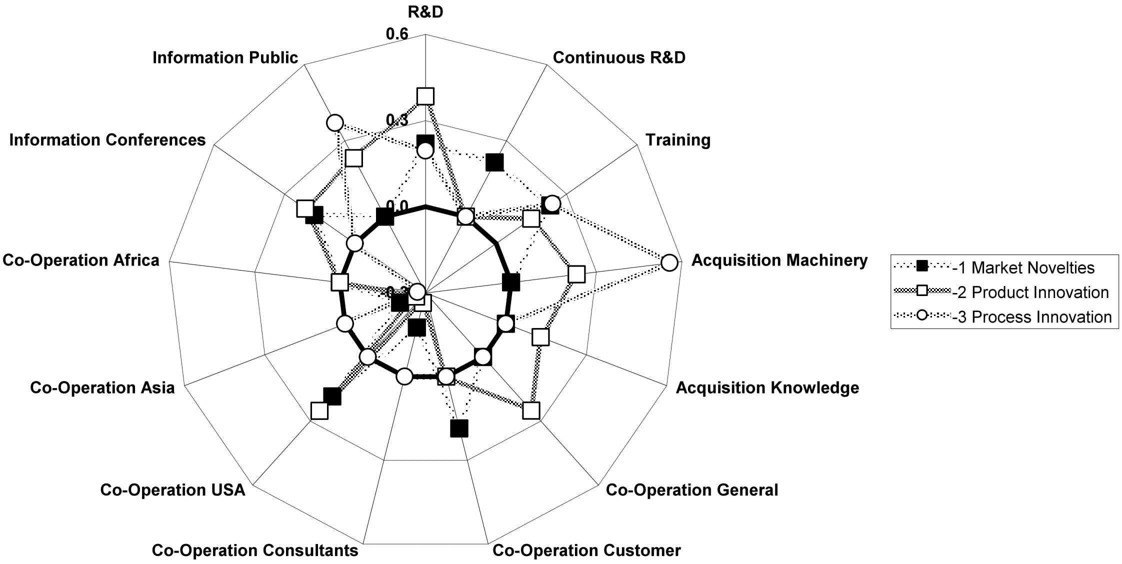
Figure 4: Knowledge Flows in South Africa



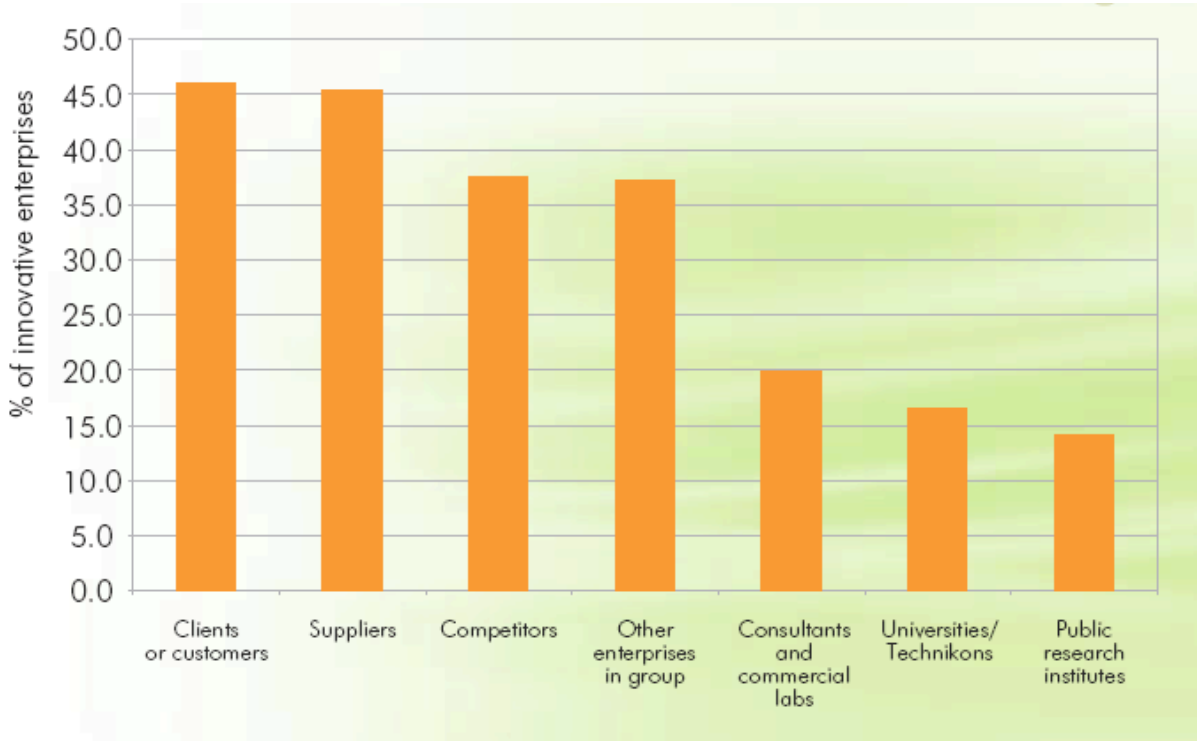
Sources: Janz, Kahn (2009)



Sources: Janz, Kahn (2009)

Figure Appendix

Figure 1: Collaborative partnerships for innovation activities in South Africa



Source: http://www.hsrc.ac.za/CCUP-59.phtml

Figure 3: Radar Plot of Innovation Source

Table 5: Probit Estimates (Marginal Effects)
of Extended Innovation Equations

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

Table 3: 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 4: Probit Estimates of Basic Innovation Equations

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

(D) indicates dummy variables, standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table Appendix

Table 1: R&D Collaboration Unique Links

Table 1a: R&D expenditure and unique links

R&D expenditure	**Unique links**
R&D > R50m	4
R10m <R&D<R50m	3
R&D< R10m	2

Table 1b: Sub-sector an Unique links

Sub-sector	**Unique links**
Chemicals	2
ICT	1
Manufacturing	2
Mining	2
Pharma	3

Table 2: 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.

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partners from North America. The overall picture shows South Africa as an active partner in international knowledge sharing. This is hardly the behaviour of a technology colony.

Strategy (DST, 2002 and Kaplan, 2004), the Ten Year Plan for Science and Technology (DST, 2008), being used as motivation to move from a negative toward a positive situation.

But the theoretical and empirical underpinnings of the 'technology colony' thesis are questionable. For a start, in and of itself a strategy of imitative and incremental innovation is not a weakness, a negative to be avoided at all costs. Many countries have evolved through this route, and some (Denmark) are highly prosperous in spite of not following the path of creative (and risky) innovation (Lundvall, 2002).

By contrast the results of the modelling show that knowledge flows within the system are significant, that innovation output is not merely imitative, and that it is far from small. Figure 2 presents a radar plot of the impact of different innovation sources on innovation, i.e. on process innovation, product innovation and market novelties. Knowledge sources are the more important the more outward the respective line is printed. Since some sources have a negative impact compared to the reference specification the zero circle is marked as bold.

Insert Figure 2 about here.

Innovation is based on indigenous knowledge creation activities in the form of firm's R&D as well as the training of personnel. The existence of continuous R&D appears to be a precondition for the successful creation of market novelties. Accordingly there is considerable knowledge flow from the world to South Africa. Isolation is a condition of the past, not the present. Acquisition of machinery as well as acquisition of other formal and informal knowledge positively influences process and product innovation, but in and of itself not market novelties. Other external sources of knowledge are of minor importance.

Most importantly, knowledge is shared internally as well as internationally through co-operation between domestic firms and firms from the rest of the world. The simple evidence of R&D collaboration is confirmed by analysis of the innovation survey metadata. A simplified presentation of innovation-relevant knowledge flows with a special focus on knowledge sharing is presented if Figure 3.

Insert Figure 3 about here.

The impact of knowledge sharing depends on type and location of the innovation partner. Knowledge sharing is mostly relevant for product innovation, not for process innovation. While co-operation in general and with most parts of the world is supporting product innovation, market novelties are mainly boosted by co-operation with customers and with

As expected, knowledge-generating activities play an important role in innovation. The R&D dummy is significant for all three activities. The 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 also a significant factor.

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 negatively 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 government laboratories foster process innovations and product innovations, but not market novelties.

7. Conclusion

De Wet (1999) speculated that the South African system of innovation should be described as a 'technology colony.' His argument rests on the observations that much local innovation is imitative and incremental in nature, that the output of the system is small, and that there seems to be a negligible flow of knowledge from research toward industrial exploitation. This thinking has been adopted in various policy documents of government, notably the R&D

labs or private R&D institutes regardless of region the partners come from, co-operation with US-American companies, co-operation with Asian companies and co-operation with African (except South African) companies regardless of the type of partner and a general dummy indicating co-operation (excluding 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.

6. Results

Probit estimates of simple innovation equations regressed on structural properties of the firm are summarized in Table 4. In line with the literature (see Cohen, 1995), we find a nonlinear U-shaped relationship on the propensity to innovate to firm size and a positive effect of skill structure. As might 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. In the latter context one notes Lorentzen (2005) who found that belonging to a multinational group is crucial for the innovative performance of automotive component manufacturers making the difference between firms innovating products and those just trying to upgrade technological capability.

Insert Table 4 about here.

Estimates of the model extended to knowledge generation and knowledge flows are summarized in Table 5. Impacts of structural properties remain mainly unchanged. The two main differences are: process innovation is independent of firm size. Moreover, effects of skill structure can only be established for market novelties, not for product and process innovation. But, variables, firm size and skill structure, correlate strongly correlate with other explanatory variables, especially with R&D. Thus, their effect is difficult to measure.

Insert Table 5 about here.

5. Empirical Model

To identify relevant explanatory factors, three equations are estimated: one for product innovation, one for market novelties and one for process innovation (according to Table 2). 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 3 summarizes these variables as well as variables characterizing firm structure and offers their characteristic descriptive statistics. Variables of these groups that are not statistically significant are excluded from Table 3.

Insert Table 3 about here.

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 that are likely to behave differently one from another: mining (SIC 21-29), electrical (SIC 36, 37) and automotive (SIC 39).

Knowledge generation comprises internal knowledge generation and external knowledge sourcing. Internally knowledge can be generated through R&D activities occasional or continuous or through training of personnel, implying three dummies in the estimation equations. External knowledge may be 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.

There is a wide literature using European CIS data on the effects of co-operation (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 dimensions and generate a group of dummy variables: co-operation with customers, co-operation with consultants, commercial

The specific aim is 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.

4. Data Set and Descriptive Statistics

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 for the years 2002-2004. The survey was based on a stratified random sample of 3087 enterprises provided by Statistics South Africa from the official business register that comprises businesses registered as taxpayers. The data was collected by postal survey with telephonic and written follow-ups as well as a non-response survey (DST, 2007). The overall response rate of 32% provides a net sample of 979 firms in manufacturing, mining and selected service sectors (Blankley, 2007, and Blankley et al., 2007).

The methodology of the survey follows the Oslo manual (OECD, 2005) with a questionnaire based on the CIS 4 core questionnaire and is comparable with CIS 4 co-ordinated by the Statistical Office of the European Communities (Eurostat).

The analysis focuses on the manufacturing and mining sectors. After adjusting the sample for item non-response to questions that are of particular interest, a sample of 360 firms, 32 mining and 328 manufacturing is obtained (Table 1). The industry classification follows the Standard Industrial Classification (SIC) scheme at 2-digit level. 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 2 includes basic information on innovation activities of firms in the sample.[2] 221 firms introduced new or significantly improved products to the market in the period 2002 to 2004. These firms are classified as product innovators. In 164 cases these products included innovations new to the market (market novelties). 215 firms introduced new methods of production, logistics, delivery, distribution or supporting activities that were new or significantly improved. They are classified as process innovators.

Insert Table 2 about here.

[2] These results are non-weighted and not extrapolated to the population of South African firms. They do not represent the South African economy.

impact of multi-nationality on the propensity to innovation, but no effect of the country of origin.

In the course of its work on the transformation and integration of the transitional and emerging economies, the United Nations Economic Commission for Europe (UNECE) implemented a monitoring system for a knowledge-based economy, concentrating on the knowledge-intensive sector within the economy, (UNECE, 2002). One of the vectors of such knowledge flows is that of foreign direct investment; another is the movement of highly skilled personnel.

The 1998/1999 World Development Report (World Bank, 1999) directly tackles the connection between knowledge and development since "it takes knowledge to transform resources we have into things we need". But, the report detected a widening knowledge gap between North and South that is not closing despite significant flows of FDI into emerging economies. Thus, acquiring and adopting global knowledge in addition to local knowledge creation is seen as crucial to build a local knowledge base. National strategies to narrow knowledge gaps are more than needed.

African states, since the decolonization from the 1950s onward have laid down goals for investment in science and technology as a factor in national development. These goals, with rare exceptions were not met. With the formation of the African Union, the successor to the Organization of African Unity has come a renewed commitment to science and technology embodied in the Consolidated Plan of Action for Science and Technology (African Union, 2005). Being convinced that the innovative capability of firms and countries is largely determined by alliances across sectors and partnerships between firms and public institutions improving regional and transnational co-operation is an explicit policy aim.

Given the dominant role of South Africa economically, as a site of knowledge production and as a site offering postgraduate education to thousands of students from the African continent, it is important to extend our understanding of the knowledge flows in its system of innovation. In addition many African states are at the early stage of mineral resources exploitation and there may be lessons for the development of their innovation systems with reference to that of South Africa.

namely more efficient production as well as new or improved products, knowledge is understood as the driving force behind sustainable economic growth. Thus, economic growth is an endogenous outcome of the generation, acquisition and transfer of knowledge in economic systems (Romer, 1994). While the importance of knowledge embodied in physical and human capital is of long-standing acceptance, the focus has broadened from knowledge creation to the study of complementing and amplifying knowledge transmission and enforcement through formal and informal networks.

The European Commission (2003) emphasizes human and social capital interactions as mutually enforcing factors building the "Knowledge Society". Social capital (Putnam, 1993 and 1994), exemplified by formal group membership or more generally defined as trust and civic norms, has been identified having a strong impact on aggregate economic activity (Knack and Keefer, 1997). While human capital is accounted a direct source of innovation and productivity growth at the micro level, social capital is facilitating co-operation and information flows permitting access to network resources. As investment in social capital is an obvious candidate for market failure, European governments support and subsidise networking and co-operation in the field of technology and innovation in various ways

After announcing the strategic goal for Europe to become the most competitive and dynamic knowledge-based economy in the world (European Council, 2000), the EU policy framework focuses on ICT and learning to develop human and especially social capital for economic growth.

Access to information and knowledge is a major issue for the creation of a knowledge-based economy, especially but not exclusively for developing countries (David and Foray, 2002 and 2003). As posited earlier economic development is strongly influenced by innovation performance that in turn depends on the creation and diffusion of knowledge. According to OECD (2004), networks for knowledge sharing are critical to innovation-led development. Stimulating knowledge transfer and promoting cross-border alliances between firms as well as between firms and universities potentially encourages the inflow of new ideas to enable and exploit domestic innovation.

Since innovation is seen as the key feature of economic growth, the role of knowledge and collaboration is a central question for the development of industries and countries (Malerba, 2007). For knowledge economies, communicative structures supporting co-operation is the passport to innovation (Dolfsma, 2008). The evidence of effects of co-operation on innovation is overwhelming. Becker and Dietz (2004). Frenz and Ietto-Gillies (2003) find a positive creation of high-level skilled jobs drew in unskilled labour so that the country's chronically high levels of unemployment would necessarily fall were the export strategy to succeed.

The OECD Review had a different focus but raised similar concerns regarding the high-level skills constraints. Where that review was more positive was in noting that the *elements* of innovation policy were in place, that a robust innovation measurement system had been developed, and that there was evidence of interactions across the system. The universities in particular did not operate in isolation. The R&D Survey evidence on collaboration would support this contention.

Regarding innovation activity, the macro-level picture from Innovation Survey 2005 is that firms disseminate innovations at a level higher than the EU average, though these are predominantly incremental in nature, much as is the case in Denmark (Lundvall, 2002). But on other indicators of innovation activities e.g. R&D, patenting, registration of designs and copyright, lower levels are reported than in the EU. Much as is the case in other emerging economies, the purchase of technology in the form of machinery, associated know-how and software is the major cost driver of innovation activities. Another aspect that stands out is the claim that the majority of firms have engaged in organizational innovation. The proportion of firms claiming this type of innovation is the highest for all countries that report on their innovation surveys. Regarding macro level collaboration partners involved as sources of innovation these mainly involve other firms, both suppliers and customers. Universities and government laboratories are mentioned as sources of innovation by fewer than 10% of respondents. This is in line with international experience. Of course universities and government laboratories are in general not directly concerned with products in the marketplace. The exception to this is the Agriculture Research Council that disseminates registered cultivars to farmers and horticulturalists.

Insert Figure 1 about here.

4. Knowledge and economic growth

We are concerned with knowledge flows so before considering the empirical evidence obtained from modelling the microdata it is useful to explore the importance of knowledge in innovation. Since the 1990s the OECD (1996) has indentified knowledge creation and knowledge diffusion as essential to economic performance. By stimulating innovation, patents are annually awarded to its inventors by the United States Patent and Trademark Office (USPTO, 2007).

Within the system of innovation are well-developed networks that support agriculture, medicine and public health, mining, defence electronics, chemicals, pulp and paper, and mineral beneficiation. The mining triple helix goes back a full century (Pogue, 2006). Strength of agricultural research is revealed in the fact that the country is ranked world fifth in the registration of Plant Breeders Rights. These networks support the international activities of South Africa's own trans-national corporations (TNCs). In keeping with the increased openness of the economy is a steady flow of funds from abroad for R&D, currently around 15% of the total. Much of these funds are directed toward clinical trials (Kahn and Gastrow, 2008).

Since 2004/05 the R&D surveys have included an item on collaboration in R&D between firms on the one side and higher education (local and foreign) and government laboratories (local and foreign) on the other. The R&D Survey item is very simple[1] and was designed merely to determine the occurrence of collaboration rather than its scale or purpose. For the firms that returned information on collaborative R&D, an interesting pattern emerges (Kahn, 2007), which reveals high levels of collaboration of R&D performing firms with the universities and government laboratories, by both local and foreign firms. Other behaviours are as might be expected namely that foreign firms tend to collaborate more with firms abroad than local firms; also that local firms have stronger connection with the local government laboratories than do foreign firms. This reflects both sectoral activity and historical relationships.

In 2007 external reviews were conducted on the economy (Hausmann, 2007) and on innovation policy (OECD, 2007). The economic review argued that sustained economic growth with job creation would depend on the country becoming an exporter of manufactured goods following the path of the East Asian tigers. The review noted the high-level skills nexus and made the case that this was the key constraint to growth. It also adduced evidence that the

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[1] Veugelers (1997) carried out econometric estimation using Flemish R&D survey data, a rare example of the application of the technique to such data sets.

in mining and mineral extraction funded by the massive rents accruing from the new Eldorado. The growth of settlements around the mines, the rigours of the compound labour system, and the incidence of mine-related diseases in turn forced the need for R&D in public health. And animal diseases arising from the interaction between wildlife and domestic livestock demanded veterinary research. Added to this was the mother of invention, namely warfare – a total of four international conflicts and a civil war during one century. The result was the formation of a small system of innovation that displays strong linkages between industry, higher education and government laboratories and that enabled self-sufficiency in most requirements of the modern state.

GDP/capita rose steadily until the mid 1950s with the promise of convergence with the wealthy North. But this was not to be. From the mid 1950s to the late 1990s GDP/capita moved sideways constrained by the gold standard, low labour productivity, the cost of apartheid, the shortage of skills and civil war. The country is now a middle-income economy whose 2005 GDP/capita stood at PPP$ 12 100 and that accounts for 22% of the continent's GDP. Mining contributes directly to 3.7% of GDP, manufacturing 16,2% while services comprise 65% (Statistics South Africa, 2007). The indirect contribution of mining to GDP is of course much higher, and its share of exports is close to 40%.

With the attainment of democracy in 1994 and the end of sanctions the economy became more open with government actively encouraging firms to invest in Africa and further afield. From the late 1990s to the onset of the global financial meltdown of 2007 the commodities boom and consumer-led growth led to steady economic growth rate averaging 4,5%. Over the same period exports in relation to GDP rose from 20% to 30% of GDP.

3. A small system of innovation

For 2006/07 gross expenditure on research and development (GERD) amounted to PPP$ 4,5 billion giving a GERD: GDP ratio of 0,95% having risen from 0,73% in 2001/02 (HSRC, 2009). The innovation is comparable in size with those of Denmark, Finland, Mexico and Turkey. The system of innovation is based on government laboratories that account for 20% of GERD, universities also at 20% and the business sector at 60%. This large role of the business sector is unusual among emerging economies, the more so as the bulk of BERD is conducted by domestic firms, not MNCs as is the case in other emerging economies such as China, Hungary, Mexico and Poland (OECD, 2008). R&D in services makes up a significant proportion (27%) of business expenditure on R&D (Kahn and Hounwanou, 2008). The country contributes around 0.5% of world scientific publications (King, 2004) and around 100

1. Introduction

With the completion of South Africa's official Innovation Survey 2005 and the creation of an anonmyized microdata set it has for the first time become possible to carry out cross-sectional econometric analysis that investigates the innovating behaviour of firms in mining, manufacturing and services. This analysis complements the growing body of literature on South Africa's system of innovation, including policy studies (Kahn, 2007; Kaplan, 2004; Walwyn, 2006) exploratory analysis of R&D survey data (Kahn and Blankley, 2005), productivity studies that include R&D as variable (Fedderke, 2001), bibliometric analysis (Pouris, 2007), patent analysis (Pouris, 2006); university-industry linkages (Kruss, 2006) and rate of return analysis (Schimmelpfenning et al, 2000). This literature describes the features of a small, functioning innovation system of an emerging economy that is increasingly open to the world. It is thus of seminal interest to explore the innovation survey microdata to determine what it adds to the understanding of this openness and the associated knowledge flows

The paper commences with some remarks on the South African economy and its 'golden goose.' Next follows a précis of what is known concerning the system of innovation system of innovation through the R&D surveys and policy studies and in particular the existence of interactions among the various actors and the partners involved in R&D collaboration. Next follows a discussion on the importance of knowledge generation, acquisition and transfer in economic growth. This sets the background for the econometric analysis of sections 4 and 5 using firm level data from the first official South African National Innovation Survey 2005 that is comparable to the Fourth European Community Innovation Surveys (CIS 4). This constitutes the first econometric study on innovation behaviour in a Sub-Saharan African country using CIS 4 type data sources. The last section summarizes the results and questions the 'technology colony' thesis of De Wet. The econometric analysis confirms the findings of the R&D surveys that R&D collaborations extend across and beyond the system and are mirrored in the innovation sourcing behaviour of firms.

2. South Africa: a Golden Goose

Nature seems to have been kind to South Africa in the form of a minerals golden goose. The minerals zoo also contains other 'golden' geese namely diamonds, platinum, titanium, chromium, manganese, molybdenum, copper, lead, germanium and uranium. Geographic isolation and unique mineralization forced the development of local technological capability

From isolation to openness: knowledge flows promoting innovation –evidence from South Africa's Innovation Survey 2005

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Abstract

This paper presents the first empirical results using the anonymized metadata of South Africa's CIS4-compatible Innovation Survey 2005. A brief discussion of the economy and the characteristics of the system of innovation is provided with special attention given to the existence of interactions among the various actors and partners involved in R&D collaboration. Next follows a discussion on the importance of knowledge generation, acquisition and transfer in economic growth. The data is modelled by three equations. The analysis shows that knowledge flows within the system are significant, that innovation output is not merely imitative and that it is far from small. The flows are both internal and with the rest of the world, confirming the tentative picture yielded by the R&D surveys from 2004/05 onward. The picture that emerges is that the country, far from being a 'technology colony' (De Wet, 1999) is an active partner in international knowledge sharing.

Keywords: innovation, knowledge, manufacturing, South Africa, survey data

JEL classification: O31, L60, C25, O55

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