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A quantitative analysis of obstacles to innovation among small, micro, and medium-sized enterprises: Evidence from South Africa

Siyasanga Qomoyi[1]*, Sikhulumile Sinyolo[2], Kgabo Hector Ramoroka[3], Amy Kahn[3] and Luthando Zondi[3]

[1]*Equitable Education and Economies, Human Sciences Research Council, Pretoria, South Africa*
[2]*Public Health, Societies and Belonging, Human Sciences Research Council, Pretoria, South Africa*
[3]*Centre for Science, Technology and Innovation Indicators, Human Sciences Research Council, Cape Town, South Africa*
**Corresponding author email: SQomoyi@hsrc.ac.za*

Firm-level innovation in sub-Saharan Africa remains under-researched. To address this gap, this paper examines the obstacles to innovation faced by small, micro, and medium-sized enterprises (SMMEs) in South Africa. Using the 2018 Business Innovation Survey, we apply the double-hurdle model to investigate factors determining a firm's decision to invest, and the intensity of innovation. Our results show that cost and institutional obstacles were significantly more important as disincentive factors for medium-sized enterprises while knowledge obstacles were significant disincentive factors for large enterprises. In addition, market obstacles hampered investment among large enterprises. Interestingly, none of these factors was found to deter innovation intensity among small and micro enterprises. The study findings suggest that there is no one-size-fits-all approach to innovation policy and intervention programmes to support innovation within firms of different sizes.

Keywords: SMMEs, innovation, deterring obstacles, revealed obstacles, innovation investment, South Africa

Introduction

Innovation plays a significant role in driving economic growth (Fu 2020) and contributes to firm performance and competitiveness (Kasongo, Sithole, and Buchana 2021) and general firm productivity (Kahn, Sithole, and Buchana 2022). The literature also emphasizes the role of SMMEs in employment generation, economic growth and development, and poverty reduction (de Kok, Deijl, and Velhuis-Van Essen 2013; Ayyagari, Demirguc-Kunt, and Maksimovic 2011; Cravo, Gourlay, and Becker 2012; Hu 2010; Bolosha, Sinyolo, and Ramoroka 2022; Mulibana and Rena 2021; Avenyo and Kraemer-Mbula 2021; Kasseeah 2013; Battersby, Marshak, and Mngqibisa 2016; Ndesaulwa and Kikula 2016; Sheikh 2019; Manyati and Mutsau 2019). SMMEs contribute over a third to South Africa's gross domestic product, and about two-fifths (40%) to employment (Mulibana and Rena 2021; Bolosha, Sinyolo, and Ramoroka 2022). SMMEs sell their goods and services in flexible and affordable quantities, and in locations close to where the poor live and work, thereby improving access to goods and services for the poor (Battersby, Marshak, and Mngqibisa 2016; Bolosha, Sinyolo, and Ramoroka 2022). Further, SMMEs establish personal relationships with their customers, which allows them to offer interest free credit arrangements (Battersby, Marshak, and Mngqibisa 2016). Thus, it is necessary to study the barriers to innovation and factors affecting the intensity of innovation among SMMEs in sub-Saharan Africa. In addition, the obstacles to innovation must be understood according to firm size class, or category.

Rapid industrial changes, competition and consumers' demands for good quality products at affordable costs, are some of the challenges that SMMEs have faced in recent times (Agwu et al. 2019). Technological change, such as artificial intelligence and automation, has affected many aspects of business in the twenty-first century. Improved and constant innovation activity is critical to address these challenges and improve a firm's competitiveness. In addition, increased SMME innovation contributes to GDP (gross domestic product), which in turn contributes to domestic employment creation. Little is known about the obstacles to innovation faced by firms in sub-Saharan Africa, although innovation is widely recognized as a major contributing factor towards firms' success (Abbey and Adu-Danso 2022).

Sub-Saharan Africa and South Africa present several studies on the determinants of innovation; however, there is limited focus on firm size and class in relation to innovation. In recent studies, Kasongo, Sithole, and Buchana (2021) and Kahn, Sithole, and Buchana (2022) found that firm size positively impacts the decision to innovate in South Africa's services and manufacturing sectors, respectively. Obstacles to innovation among different firm sizes are not clearly distinguished in current research in South Africa. In this study we investigate the decisions made by SMMEs to invest in innovation and factors affecting the intensity of the firms' innovation, to understand the obstacles faced by different firms. Are SMMEs facing similar obstacles to innovation as large firms? The extant literature shows that several factors drive or inhibit SMME innovation. However, most of this work is based on developed countries (e.g., Coad, Pellegrino, and Savona 2016; Arza and Lopez 2021). Our understanding of the determinants of and obstacles to innovation is therefore obtained in a developed country context and may not be appropriate for innovation in less developed countries in Africa (Fu 2020).

In South Africa and many other countries, SMMEs make up an important part of the private sector. According to Fongwa and Fohtung (2013), sub-Saharan African countries have started to recognize SMMEs as key drivers of the economy. In South Africa in 2015, Stats SA reported 2,251,821 SMMEs of which 667,433 were

formal and 1,497,860 informal (Bureau for Economic Research 2016). Although there is a high number of SMMEs in South Africa it is also reported that 70% to 80% of SMMEs collapse in the first year of operation (Mulibana and Rena 2021). Nonetheless, research shows that small businesses that engage in innovation are more likely to succeed or survive than those that do not engage in innovation (Mhula-Links, Hart, and Jacobs 2014).

While innovation has been recognized as a contributing factor to successful businesses, SMMEs face many challenges in creating high value and market-oriented innovations. In the same vein, research (e.g., Agwu et al. 2019) highlights different characteristics that influence a firm in its innovation strategies. For this reason, it is important to understand obstacles to innovation faced by firms of different sizes. The challenges faced by firms have been exacerbated by rapid technological advancement and globalization (Agwu et al. 2019) but how firms of different sizes overcome such challenges in low-income countries remains poorly understood.

This paper seeks to contribute to addressing two research gaps. First, the study acknowledges that much about innovation drivers and sources has been learned from studies that focus exclusively on the innovation challenges that face SMMEs in developed countries. Therefore, this study aims to participate in closing this gap by providing an analysis of data in the sub-Saharan African context. Second, the study acknowledges existing research on the obstacles and challenges of innovation among SMMEs but argues there is little research that considers heterogeneities according to firm size when investigating a firm's decision to engage in innovation activities. In addressing this gap, the current study applies a double-hurdle model and investigates the obstacles affecting innovation and innovation intensity among SMMEs in South Africa.

Theoretical background and literature review

Theoretical framework

The study adopts a systems of innovation approach to understand the obstacles to innovation among SMMEs, following several other studies (e.g., Arza and Lopez 2021). Lundvall (1992) defined an innovation system as 'the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge'. As Edquist (2006) highlighted, the innovation systems approach is widely used in academic and policy circles because of its strengths. These include the holistic, interdisciplinary and evolutionary perspective it adopts, its emphasis on learning processes and the role of institutions, and the non-linear perspective it offers to innovation. The evolutionary perspective stresses that innovation processes occur over time and are influenced by several factors and feedback processes (Edquist 2006). The importance of firm capabilities, interactions and networking, learning, as well as the institutional set up, are also emphasized (Nelson 1985; Lundvall 1992).

The innovation systems approach recognizes that innovation is not just a product of the individual actions of firms, but also of interactions among various actors, such as research institutions, government agencies, competitors, suppliers, etc. The holistic nature of the innovation systems approach allows for the identification of a wide array of innovation obstacles across the organizational, social, political, and economic spheres that most small and medium enterprises face. A firm's decision to engage in innovation compels it to overcome internal and external challenges (Arza and Lopez 2021). Recent literature has emphasized the importance of distinguishing deterring and revealed obstacles to innovation (Arza and Lopez 2021). The former are barriers that hinder some firms from initiating innovation activities, while the latter are experienced by those firms who have passed the first hurdle and are engaged in innovation activities. Firms in developing countries also generate resources and capabilities to appropriate economic value and become more innovative (Goedhuys, Janz, and Mohnen 2014). How they create firm-level resources for innovation includes internal R&D, entrepreneurial skills, and a variety of input factors. Firms require a unique set of innovation relations, capabilities, and resources, for them to engage in innovative activities regardless of their size (Saka-Helmhout, Chappin, and Vermeulen 2020).

Literature review

Academic interest in the determinants of and barriers to innovation is not a recent phenomenon and dates back to the 1980s (Arza and Lopez 2021). Nonetheless, the study reviews more recent literature, from 2000, in both developed and developing country contexts. The OECD (2005) notes that several factors including economic factors, such as high costs, or factors specific to an enterprise such as a lack of skilled personnel or knowledge as well as legal factors such as regulations and tax rules hinder innovation activities. Savignac (2008) examined the impact of financial constraints on the propensity of French manufacturing firms to engage in innovation activities. The study restricted the sample to firms that wished to innovate and used a recursive bivariate probit model.

The results indicated that the likelihood that firms will engage in innovative activities is reduced by financial constraints. Similarly, Blanchard et al. (2013) distinguished between firms that intend to innovate and those that do not innovate when they assessed the impact of obstacles to innovation on French firms' propensity to innovate. The study utilized the French Community Innovation Survey (CIS4) and analyzed it using a bivariate probit regression model. The variables considered included firm size, research and development (R&D) intensity, group affiliation, and region. The results indicated that the intensity of R&D plays a significant role in firms' propensity to innovate. Larger firms are more R&D intensive, thus, their ability to innovate is high. Firms that invest large amounts in R&D engage in several innovative projects and are more likely to face obstacles as they engage in innovation.

Furthermore, the impact of a firm's size on their probability of facing obstacles was significantly negative when

using the sample of the firms willing to innovate, but size did not appear to have significant effects when the full sample was used (Blanchard et al. 2013).

These studies paid attention to firm size classes and how factors such as cost, market, R&D intensity as well as group affiliation influence innovation activity. A study published by the OECD in 1997 argues that SMMEs are generally more market and less research-driven compared to large companies; they are quick to respond to new opportunities and are oriented to achieving small, incremental advances. The results also indicated that being part of a group assists in reducing the likelihood of facing obstacles.

The predominantly studied and identified obstacles to innovation are cost, knowledge and regulation factors (Galia, Mancini, and Morandi 2012). Nizaeva and Coskun (2018) analyzed the determinants of financial obstacles faced by SMMEs in selected emerging economies in the Western Balkan region of Europe using an ordered probit model. The main determinant of financial constraints for SMMEs in the selected economies was firm size. Ownership type, firm age, accounting information, transparency, the depth of credit information indexes, banking sector concentration, property registration costs and per capita GDP were other observed determinants of financial constraints.

Pellegrino and Savona (2017) assessed the barriers that constrain firms' investment in innovation activities using panel data from the UK Community Innovation Survey (CIS). They employed the same sampling strategy used by Savignac (2008) and excluded firms that were not innovation oriented, focusing on firms willing to innovate (measured as having introduced a new product or process or engaged in innovation activities while experiencing at least one of the barriers to innovation). The study applied a pooled probit model to analyze the data. Financial obstacles were found to significantly reduce the probability of translating innovative efforts into innovation outputs. Furthermore, firms experiencing market-related obstacles were observed to be less likely to introduce any kind of innovative product or process than firms that did not experience market-related obstacles. A firm's propensity to introduce an innovative product or process was also significantly reduced by regulatory barriers.

Uvarova and Vitola (2019) used qualitative methods including desktop research, focus groups, and semi-structured interviews with various stakeholders to identify the main challenges and opportunities for the introduction of innovation in European rural SMMEs. The main identified shortcomings that challenged SMMEs included the environment for innovation (the lack of innovation culture and low interest in innovative solutions), inappropriate innovation policies and support measures, lack of knowledge and skills within companies, difficulties in employing new skilled labour, and a weak capacity to be competitive. Arza and Lopez (2021) studied obstacles that affect and prevent investment intensity in the innovation of firms of different sizes in Argentina's manufacturing sector and also distinguished between firms that engage in innovation activities and those that do not. Factors such as cost, market and institutional obstacles were identified in the findings as deterrents to innovation, while knowledge and market obstacles affected investment intensity in innovation. Cost obstacles affected smaller firms' investment decisions more than larger firms.

Countries in the Global South are also characterized by low levels of productivity, with labour productivity extremely low compared with countries in the Global North. Countries in the Global South lack broader factor inputs such as managerial competencies, access to information, worker motivation and institutional flexibility (Odeh 2010). Poor government policies, poor infrastructure, and lack of adequate formal and vocational education, which then hinder technology adoption, are also factors that explain the difference in productivity in these countries (Mugogo and Midala 2020).

Elmansori and Arthur (2014) used a snowball approach to survey SMMEs in Libya to identify obstacles to innovation. The shortage of financial resources, lack of innovation culture in Libyan education institutions and the shortage of skills in innovation management were identified as major obstacles to innovation. Other factors hindering innovation were insufficient use of public procurement to foster innovation in SMMEs, a shortage of skills to manage intellectual property and knowledge, and insufficient knowledge about innovation support services.

Nmadu, Sallawu, and Omojeso (2015) analyzed the socio-economic factors affecting the adoption of innovation by cocoa farmers in Nigeria through descriptive statistics and multinomial logistic regression using data from structured interviews. The adoption rate was found to be low, and gender, as well as the level of education of the farmers, were the main factors that affected the decision to adopt innovation. Almost two-thirds of the farmers were male and 70% had only primary school education.

Elmansori and Arthur (2014) also observed socio-economic factors, highlighting that the ownership of SMMEs in Libya was largely dominated by men and due to culture, religion, and family responsibilities, women were likely to face more constraints to innovation.

Mugogo and Midala (2020) used qualitative and quantitative approaches to examine the barriers to SMME innovation performance in Zimbabwe. They identified economic factors such as lack of finance and the high cost of innovation as key factors that constrain SMME innovation.

The topic of barriers to innovation in SMMEs has not been studied extensively in South Africa and studies that explored barriers to innovation did not specifically focus on innovation obstacles for SMMEs. Some studies have investigated the use of open innovation (Krause, Schutte, and du Preez 2012) as well as challenges to ICT adoption and use, particularly in the manufacturing sector (Pillay and Barreira 2016; Gono, Harindranath, and Ozcan 2013). Few South African studies use quantitative methods to assess obstacles affecting SMMEs' decisions to innovate.

Ngibe and Lekhanya (2019) investigated the challenges to innovation leadership in South African manufacturing SMMEs using the factors analysis test. The results indicate that factors that affect innovative leadership in manufacturing SMMEs include education and training, leadership and technical skills, a lack of financial assistance, the effects of the South African Revenue Service, and the inability to adapt to ICT. A policy brief by Sithole et al. (2018) assessed how cost, knowledge, and market barriers are perceived depending on factors such as the number of innovation activities of SMMEs, the number of employees, being part of a larger group, the extent of an international corporation, the number of types of cooperation partners as well as sources of information. Cost barriers are experienced more significantly by SMME start-ups than established companies, and companies with international and other partnerships are less likely to experience cost barriers than companies without partnerships. Companies that innovate are also more reliant on qualified employees than companies that do not innovate.

Cost or financial obstacles are the most prevalent determinants of a firm's decision to innovate in many of the studies. The size of the firm is a significant determinant of the extent of the cost obstacle – smaller firms are more financially constrained than larger firms. The financial burden of innovation diminishes the innovation activity of firms. Small innovative firms face challenges such as a lack of grants and venture capital, inefficient information exchange in the community, and investor decision-making capacity (Butryumova et al. 2015).

Chundakkadan and Sasidharan (2020) studied the relationship between financial constraints, government support, and firm innovation in developing countries. The authors found that financial constraints were obstacles to innovation for small and medium enterprises. Furthermore, lack of finance is prominent in young and small firms due to information asymmetry (moral hazards) in the credit market and hampers investment in innovation activities in these firms. Ayalew and Xianzhi (2019) studied the effect of financial constraints on innovation in selected African countries. They found that access to finance is an obstacle to innovation and reduces the likelihood of firms introducing new or improved products or processes.

Similarly, Sharma (2017) examined managing innovation in micro, small, and medium enterprises in the Middle East and North Africa (MENA). The study found that obstacles to innovation include lack of coordination (action and policy) frameworks to promote SMME innovation policies, scarcity of skilled human resources in innovation management, competition, improper access to markets, high barriers to entry, lack of financial resources, insufficient use of public procurement to foster innovation in small-medium enterprises, and the lack of infrastructure and technological support services.

Oudgou (2021) also examined the financial and non-financial obstacles to firms' innovation in the MENA region. The study found that small firms are more innovative. The impediments to innovation in all firm sizes include business environment factors such as access to electricity, corruption, labour regulations, inadequate human resources, and political instability. In Russia, Dubrova, Ermolina, and Esenin (2019) found low innovation activity among small businesses due to financial constraints (insufficient development of credit finance), poor business cooperation, and a weak technological and production base.

Research methodology

Data

The paper uses secondary data from the Business Innovation Survey (BIS), which is conducted approximately every three years by the Centre for Science, Technology, and Innovation Indicators (CeSTII) in the Human Sciences Research Council of South Africa. The survey is conducted on behalf of the Department of Science and Innovation, and follows the methodological guidelines set out by the OECD's Oslo Manual. The survey round conducted in 2018, covering the 2014–2016 reference period, is used in this analysis.[1]

Following the guidelines of the Oslo Manual 2005, the study population is the business enterprise sector, including manufacturing, primary industries and services. The national business register held by Statistics South Africa provided the sample frame. A stratified random sample of firms was drawn according to Standard Industrial Classification (SIC) codes and firm size (CeSTII 2020). The sample frame included 30 SIC codes in industry sectors (mining, manufacturing, and electricity, gas, and water supply) as well as services sectors (wholesale and retail trade, transport, storage, and communication, financial intermediation, and computer and related activities) and the firms were divided into four size classes (micro, small, medium, and large) based on turnover.[2] Thus, there were a total of 120 strata in the frame. From the initial sample of 4 950 firms drawn, 759 were discarded as duplicates, inactive, or not traceable, resulting in a final survey sample of 4 191 enterprises. A total of 642 enterprises responded to the survey, which achieved an overall response rate of 15%.

To address any bias due to potential systematic differences between firms who responded and those who did not, a simple random sample non-response survey was conducted (CeSTII 2020). The Oslo Manual (OECD 2005) recommends this for business innovation surveys with response rates below 70%. The non-response survey targeted 493 (15% of the enterprises that did not respond to the main survey), and achieved a response rate of 68%. The probability weights were then adjusted to correct for non-response bias, so that the final sample was representative of the manufacturing and service industries in South Africa.

From the initial sample of 642 firms, a total of 81 firms were excluded because they did not engage in any innovation activity and did not identify any obstacles, following previous studies (e.g., Arza and Lopez 2021; Savignac 2008; Pellegrino and Savona 2017; Blanchard et al. 2013) that investigated innovation obstacles. The relevant subsample included 561 firms defined as willing to innovate or potential innovators. The potential innovative firms included those engaged in innovation activities in the

2014–2016 period, had ongoing, successful, or abandoned innovations, and experienced at least one of the barriers to innovation. A total of 15 firms did not have data on key variables and were dropped from the analysis, resulting in a final sample of 546 enterprises.

For the analysis, we used employment numbers to categorize the firms into three classes: micro and small enterprises (0–50 employees); medium enterprises (51–250 employees); and large enterprises (over 250 employees). The micro and small enterprise categories were merged because we received only a few responses from the former.

Econometric model and variables

The decision to invest in innovation activities was modelled as a two-step decision process: (1) the firm decides whether to invest and (2) the firm decides on the amount to be invested (i.e., innovation intensity). The double-hurdle model (Cragg 1971) was used to model this two-step decision process. This model was chosen over the Heckman sample selection model. The Heckman approach addresses the statistical challenge posed by cases where zero investments are made as a missing data problem. However, the issue of zero investments does not represent missing values since a zero amount of investment is a valid economic choice to be explained. The double-hurdle model produces superior estimates over the Heckman model when one is dealing with true zeros (Dow and Norton 2003).

According to the double-hurdle model, firms face two hurdles while deciding to innovate, specifically, whether to undertake any innovation investment activity and how much investment to make. This approach allows for distinguishing between fixed transaction costs, which influence only the first decision, and variable transaction costs, which can influence both decisions. In the decision stage (the first hurdle), the obstacles act as a deterrence to innovation undertaking, while they constitute revealed obstacles in the second stage (second hurdle) (Arza and Lopez 2021).

The double-hurdle model integrates and simultaneously estimates the probit model to determine the probability of innovation investment ($innov\_act\_dec_i$) and the truncated normal model for the level of investment activity ($innov\_act\_intensity_i$). The binary variable of the decision to innovate ($innov\_act\_dec_i$), assumed to follow a probit model, was specified as follows:

$$innov\_act\_dec_i = 1[\gamma_0 + \gamma_1 obst_i + \gamma Z_i + u_i] \quad (1)$$

where: $innov\_act\_dec_i$ is a binary variable capturing the decision to invest in innovation activities, which takes the value 1 if firm i engaged in at least 1 innovation activity, and 0 otherwise; $obst_i$ are innovation obstacles experienced by firm i; Z_i is a vector of a firm, institutional and market characteristics that affect innovation; γ are the coefficients to be estimated and u_i is the error term.

The level of investments, $innov\_act\_intensity_i$, assumed to have a truncated normal distribution with parameters that vary freely from those in the probit, was estimated as follows:

$$innov\_act\_intensity_i = \beta_0 + \beta_1 obst_i + \beta x_i + \varepsilon_i \quad (2)$$

where: $innov\_act\_intensity_i$ represents innovation intensity (total amounts in rand invested in innovation activities per employee); $obst_i$ are innovation obstacles experienced by firm i; x_i is a vector of the firm, institutional and market characteristics that affect innovation; ε_i is the error term, and β's are parameters that were estimated.

Table 1 presents the description of the key variables that were used. The decision to innovate variable (innov_act_decision) refers to those enterprises that engaged in at least one innovation activity. The innovation activities include intramural (in-house) research and experimental development (R&D), extramural or outsourced R&D, acquisition of advanced machinery and equipment, acquisition of new buildings, acquisition of other external knowledge, internal or external training for personnel, market introduction of innovations, other in-house or contracted out activities, lease or rental of machinery, equipment and other capital goods, acquisition of computer hardware, acquisition of computer software, in-house or contracted out activities to alter the shape, appearance or usability of goods or services and engineering activities. The innovation intensity variable (innov_act_intensity) captured the amounts in rand spent by enterprises on innovation activities divided by the total number of employees.

Firms were asked to identify the factors that hamper innovation, and to rate the importance of the factors (i.e., 0 = factor not experienced, 1 = low, 2 = medium, and 3 = high). The specific obstacles were grouped into four categories: cost, knowledge, market, and institutional factors, using standardized values, following Arza and Lopez (2021). The indexes measure the intensity of obstacles as perceived by firms.

Control variables included the number of employees, human capital, firm age, part of an enterprise group, information sources, foreign-owned, and exporter. The information sources variable (info_sources) captures the number of information sources that were important for the enterprise's innovation activities. The potential information sources include the following: sources within the enterprise or enterprise group; suppliers of equipment, materials, components, or software; clients or customers; competitors or other enterprises in the sector; consultants, commercial laboratories; universities/higher education institutions; government or public research institutes; private research institutes; conferences, trade fairs, exhibitions; scientific journals and trade/technical publications; and professional and industry associations. The info_prop variable captures the proportion of the above information sources that were considered important by the firms.

Results and discussions

Descriptive summary

Table 2 presents the descriptive statistics for the variables in the model, and the differences between small, micro, and medium enterprises and larger enterprises.

Table 1: Description of key variables.

Variable code	Variable description
Dependent variables	
innov_act_decision	Engaged in at least 1 innovation activity between 2016–2018 (1 = Yes)
innov_act_intensity	Innovation activity exp. per employee (R'000)
Innovation obstacles variables	
zcost _index	Intensity of costs obstacles (*z*-values)
zknow _index	Intensity of knowledge obstacles (*z*-values)
zmkt _index	Intensity of market obstacles (*z*-values)
zinst _index	Intensity of institutional obstacles (*z*-values)
zall _index	Intensity of at least one obstacle (*z*-values)
Other explanatory variables	
employees	No. of firm employees in 2016
human_capital_prop	Proportion of employees with a degree or diploma in 2016
firm_age	Age of firm in 2016 (years)
group	Firm is part of an enterprise group (1 = Yes)
info_sources	Total number of information sources used
info_prop	Proportion of information sources used
foreign_owned	Foreign-owned (1 = Yes)
exporter	International market main market for the firm (1 = Yes)
SIC Code	
2	Mining and quarrying
3	Manufacturing
4	Electricity, gas, and supply
6	Wholesale and retail trade
7	Transport, storage, and communication
8	Finance, insurance, real estate, and business services

The F-test statistics indicate that cost and market obstacles are significant across micro and small enterprises as well as medium and large enterprises. The results from the table indicate that on average, the enterprises included in the sample are relatively old, having existed for about 29 years. Small and micro enterprises and medium enterprises are relatively younger, with years of existence ranging on average from 17 to 26 years, compared to larger enterprises that have been in existence for an average of 42 years. On average, the number of employees of the enterprises was just under 900; however, when observing the employment levels of the different size categories, we see that small and micro enterprises employ fewer personnel (an average of 22) while medium enterprises employ an average of 130 employees. Large enterprises on the other hand employ more personnel (more than 2 500 personnel on average). On average, 19% of the personnel in the enterprises possess a degree or diploma. However, small, and micro enterprises have a higher proportion of personnel with degrees or diplomas than medium and large enterprises.

In terms of innovation decisions, it is estimated that 79% of the enterprises were engaged in at least one innovation activity but small and micro enterprises are less likely to be engaged in innovation activities than medium and large enterprises. The innovation intensity of medium enterprises is much greater than that of small and micro enterprises. The innovation intensity of large enterprises is much lower than both small and micro enterprises and medium enterprises, which may partly be due to their much larger numbers of employees.

Table 2: Summary of key variables by enterprise size category ($n = 561$).

Variable	All enterprises	Small & micro enterprises	Medium enterprises	Large enterprises	*F*-test
innov_decision	0.79	0.66	0.82	0.88	0.000***
innov_intensity	286.55	130.85	578.21	88.12	0.314
Innov_exp (mil)	50.43	4.23	45.36	86.82	0.029**
employees	888.15	21.66	129.26	2514.20	0.000***
human_capital	0.19	0.24	0.18	0.16	0.005***
ent_age	28.93	17.15	26.43	42.24	0.000***
group	0.54	0.39	0.51	0.72	0.000***
exporter	0.16	0.16	0.12	0.21	0.061*
info_sources	5.49	3.53	5.51	7.19	0.000***
info_prop	0.50	0.32	0.50	0.65	0.000***
cost_obstacles_sum	4.85	4.57	4.78	5.17	0.454
know_obstacles_sum	4.98	3.99	4.89	5.96	0.000***
mkt_obstacles_sum	4.85	4.98	4.51	5.13	0.199
inst_obstacles_sum	2.41	2.30	2.24	2.71	0.124
all_obstacles_sum	17.09	15.83	16.42	18.97	0.028**

Notes: ***, **, and * means significant at 1%, 5%, and 10% levels, respectively.
Source: Business Innovation Survey (CeSTII 2020).

Table 3: Determinants of probability and levels of innovation activities, all firms.

	Decision to invest	Innovation intensity
zcost_index	−0.038	0.100
	(0.076)	(0.141)
zknow_index	−0.188**	0.008
	(0.096)	(0.161)
zmkt_index	0.016	−0.251
	(0.084)	(0.167)
zinst_index	−0.168*	0.071
	(0.091)	(0.162)
lnent_age	−0.022	−0.081
	(0.089)	(0.156)
info_prop1	3.551***	1.249***
	(0.249)	(0.493)
human_capital_prop1	0.172	1.666***
	(0.292)	(0.496)
group	−0.193	−0.105
	(0.125)	(0.237)
exporter	0.146	0.202
	(0.174)	(0.295)
employees	0.000	0.000***
	(0.000)	(0.000)
_cons	−0.858**	9.174***
	(0.379)	(0.775)
lnsigma		
_cons	0.667***	
	(0.040)	
/sigma	1.949	
	(0.078)	
Sector controls	Yes	Yes
Number of obs	489	
LR chi2(15)	465.59***	
Pseudo *R*2	0.0583	
Log likelihood	−3761.67	

Notes: ***, **, and * means significant at 1%, 5%, and 10% levels, respectively.
Source: Business Innovation Survey (CeSTII 2020).

Cost, knowledge, and market obstacles were experienced by more than 71% of the enterprises and these obstacles are statistically significant.

Higher proportions of medium and large enterprises indicated that they experienced cost obstacles than small and micro enterprises, while a large proportion (82%) of large enterprises indicated that they experienced knowledge obstacles. Cost obstacles are the only obstacles where the size of the firm plays a significant role in the decision to innovate (Arza and Lopez 2021). Cost obstacles are significantly more important as a deterrent factor for SMME's decision to innovate than for large firms (Arza and Lopez 2021). More than 80% of small and micro as well as large enterprises experienced market obstacles, while 72% of medium-sized enterprises experienced the same obstacle. Institutional obstacles seem to be less prevalent on average but 70% of large enterprises indicated that they experienced this obstacle, compared to 60% of small and micro enterprises and medium enterprises.

Econometric results

The results for determinants of the probability and level of innovation for all the firms is presented in Table 3. The results show that the importance of knowledge and institutional obstacles were negative and statistically significant in the decision equation, while the cost and market obstacles were insignificant. The results imply that knowledge and institutional obstacles were associated with reduced chances of firms investing, suggesting that these obstacles are a key deterrent to investment in innovation activities by firms. However, once the decision to invest has been made, the results indicate that none of the obstacles plays a significant role in the intensity of investment. In comparison, Pellegrino and Savona (2017) found that knowledge obstacles did not show a significant relationship with the decision to invest in innovation, while knowledge and market obstacles were found to be significant barriers to the decision to innovate (Arza and Lopez 2021). Arza and Lopez (2021) further explain that deterrent obstacles are those that prevent innovation, while revealed obstacles are those that affect the intensity of firms' efforts to innovate. Knowledge obstacles were also statistically more significant compared to institutional obstacles (Arza and Lopez 2021).

Firms who relied on relatively higher proportions of information sources were more likely to decide to invest in innovation activities, but also invested at higher levels. SMMEs rarely interact with institutions outside the business sector (e.g., universities, contract research organizations, technology centres, and training institutions). Thus, information and knowledge tends to be restricted to the well-known market, leading to a dependency on either strong business partners or small markets for specialized products or services, without the

Table 4: Determinants of probability and levels of innovation activities by firm size category.

	Micro and small firms		Medium firms		Large firms	
Variables	Decision to invest	Innovation intensity	Decision to invest	Innovation intensity	Decision to invest	Innovation intensity
zcost_index	0.111	0.034	−0.225*	−0.220	−0.095	0.382*
	(0.158)	(0.287)	(0.129)	(0.215)	(0.171)	(0.227)
zknow_index	−0.283	−0.078	0.127	−0.200	−0.415*	0.123
	(0.205)	(0.378)	(0.156)	(0.260)	(0.219)	(0.238)
zmkt_index	−0.290	−0.491	−0.155	0.022	0.454***	−0.413
	(0.193)	(0.369)	(0.158)	(0.243)	(0.175)	(0.302)
zinst_index	−0.067	0.130	−0.334**	0.344	−0.157	0.164
	(0.225)	(0.352)	(0.155)	(0.254)	(0.219)	(0.261)
lnent_age	0.114	−0.129	−0.439***	−0.676**	0.166	0.410*
	(0.211)	(0.356)	(0.169)	(0.271)	(0.166)	(0.251)
info_prop1	4.607***	2.511***	3.264***	1.862**	3.739***	−1.154
	(0.931)	(0.898)	(0.451)	(0.751)	(0.467)	(1.027)
human_capital _prop1	0.039	0.379	0.378	1.805**	−0.051	1.491
	(0.657)	(0.908)	(0.575)	(0.816)	(0.943)	(1.054)
group	−0.197	−0.289	0.069	−0.235	−0.591*	0.261
	(0.285)	(0.510)	(0.217)	(0.360)	(0.341)	(0.401)
exporter	0.356	0.811	1.121***	0.097	−0.177	0.167
	(0.342)	(0.602)	(0.372)	(0.479)	(0.336)	(0.450)
employees	0.024*	−0.003	0.005**	0.000	0.000	0.000**
	(0.014)	(0.020)	(0.002)	(0.003)	(0.000)	(0.000)
_cons	−6.487	9.050***	−0.344	10.567***	−0.433	9.436***
	(260.31)	(1.147)	(0.947)	(1.384)	(0.959)	(1.229)
lnsigma						
_cons	0.611***		0.606***		0.624***	
	(0.083)		(0.064)		(0.065)	
/sigma	1.842		1.833		1.867	
	(0.153)		(0.118)		(0.121)	
Sector controls	Yes		Yes		Yes	
Number of obs	139		180		170	
LR chi2(15)	178.64***		179.35***		171.49***	
Pseudo *R*2	0.0928		0.0572		0.0592	
Log likelihood	−873.60		−1477.53		−1362.95	

Notes: ***, **, and * means significant at 1%, 5%, and 10% levels, respectively.
Source: Business Innovation Survey (CeSTII 2020).

ability to substitute in case the market fails (Kaufmann and Todtling 2002).

Firms with more employees were likely to invest more than those with fewer employees, among those investing. However, the number of employees did not significantly influence the decision stage of the process. A higher proportion of employees with degrees or diplomas (human capital) was associated with higher innovation investment intensity levels for the firms that had already decided to invest. However, human capital did not seem to play a significant role in the decision stage. According to Kaufmann and Todtling (2002), small, micro and medium enterprises innovate with higher intensity than large firms. Human capital plays a key role in influencing the intensity of innovation, which indicates a need for more qualified employees (Kaufmann and Todtling 2002). In addition, SMMEs are usually unable to organize in a way that enables them to benefit from specialization to the same extent as larger firms due to a limited resource base regarding capital and the know-how of the employees (Kaufmann and Todtling 2002). Firms with more highly educated employees are more likely to face the challenge of a shortage of qualified employees, revealing that firms with more knowledge, position themselves within niches where knowledge issues are more challenging (D'Este, Rentocchini, and Vega-Jurado 2014 as cited in Coad, Pellegrino, and Savona 2016). In addition, Coad, Pellegrino, and Savona (2016) assert that firms with more highly educated employees are susceptible to other obstacles such as availability of finance, a market dominated by established firms, and regulatory barriers.

Table 4 displays the results presented according to the firm size category. The results show that for micro and small firms, the obstacles do not play a significant role in both the decision and intensity stages. This differs among medium-sized firms, where the cost and institutional obstacles are associated with reduced chances of firms deciding to engage in innovation activities. However, once the decision to invest has been made, none of the obstacles plays a significant role. Among large firms, knowledge obstacles reduce the likelihood of firms deciding to invest. In contrast, market obstacles are associated with an increased likelihood to invest among large firms. Similarly, firms facing cost obstacles were more likely to invest in innovation activities. These results contrast with Arza and Lopez (2021) who found that cost obstacles were more critical as deterrent obstacles for SMMEs,

reducing the likeliness to invest, but were not statistically significant for large firms. Pellegrino and Savona (2017) also found that financial obstacles significantly reduce both small and large firms' probability of innovating. Financial and non-financial obstacles were found to play a significant role in hampering the innovation performance of French small and large firms (Blanchard et al. 2013).

Institutional obstacles are significant for medium-sized firms' decision to innovate. On the other hand, information sources are important in the decision to invest as well as the innovation intensity of micro and small enterprises as well as medium firms, while this is only significant for innovation intensity for large firms. Human capital is a significant obstacle for medium-sized firms' innovation intensity. The results show that belonging to a group plays a significant role in large firms' decision to invest, in that the likelihood to invest in innovation is low if they are part of an enterprise group. The number of employees is a significant determinant of micro and small as well as medium-sized firms' decisions to invest, while it is a significant determinant of innovation intensity among large firms.

Obstacles to innovation

The literature has indicated that enterprises face various barriers that affect their innovation activities (OECD 2005) and their decision to engage in innovation (Kasongo, Sithole, and Buchana 2021). It has also indicated that various obstacles affect enterprises' innovation activities (OECD 2005) and their decision to engage in innovation (Kasongo, Sithole, and Buchana 2021). SMMEs share features that place them at a disadvantage compared to larger enterprises. Therefore, larger enterprises are expected to invest more in innovation than SMMEs (Arza and Lopez 2021). Our paper contributes to the empirical literature on the obstacles to innovation among SMMEs in the developing country context in sub-Saharan Africa.

The double-hurdle model (Cragg 1971) was applied to investigate the firm's decision on whether to invest, and the firm's decision on the amount to be invested. The results from the model show diverse obstacles affecting SMMEs' innovation processes.

The results from the model showed that overall, knowledge and institutional obstacles were negative and statistically significant in the decision equation, while the cost and market obstacles were insignificant. The results imply that knowledge and institutional obstacles negatively influenced enterprises' decisions to invest in innovation. The results further revealed that these obstacles did not play a significant role after an enterprise has decided to invest. Furthermore, firms that relied on relatively higher proportions of information sources were more likely to decide to invest in innovation activities but also invest at higher levels. This demonstrates the importance of a variety of sources of knowledge and information.

We explored heterogeneities according to firm size category (SMMEs), and the results showed that for micro and small firms, obstacles do not play a significant role in both the decision and intensity stages. According to Gimenez-Fernandez, Sanduli, and Bogers (2020), existing literature does not indicate which resources are better when providing support to small enterprises. In their recent study, Gimenez-Fernandez, Sanduli, and Bogers (2020) found that start-ups will benefit more from innovation support from policy instruments that enhance external knowledge orientation than the enterprise's internal research and development. The analysis of different categories of firms showed that medium-sized firms are hampered by cost and institutional obstacles when deciding to engage in innovation activities. However, once the decision to invest has been made, none of the obstacles plays a significant role. We found that knowledge obstacles reduced the likelihood of large firms investing in innovation activities. In contrast, market obstacles are associated with an increased likelihood of investing among large firms. Similarly, firms facing cost obstacles were likely to invest more in innovation activities.

The literature reviewed supported some of these findings. For instance, the significance of cost obstacles among medium-sized firms is consistent with the findings of a study by Savignac (2008) where financial constraints were found to negatively affect innovation efforts. The finding that institutional obstacles are significant in the decision to invest in innovation is backed by Roper and Arvanitis (2012), who argue that the institutional context within which an enterprise or firm operates can hinder or enhance innovation. Market obstacles were also found to increase the propensity to invest among large enterprises. Small enterprises, on the other hand, did not consider the obstacles as deterrent factors to innovation, although the literature reviewed indicated that obstacles, particularly financial obstacles, tend to hamper the innovation capabilities of smaller enterprises.

An initial step toward highlighting suitable policies that support firms to participate in innovation activities, considering their size and their different stages of existence, is the identification of the specific obstacles that affect different firms (Coad, Pellegrino, and Savona 2016), which this paper has presented. At the same time, the heterogeneity of the SMME sector presents a challenge in targeting innovation support for SMMEs that matches the specific challenges and needs of very different firms (Kaufmann and Todtling 2002). However, government can encourage the development of SMMEs and their participation in innovation activities through better access to institutional support and information by connecting SMMEs to research institutes such as universities and offering financial support and incentives to SMMEs with an interest in participating in innovation activities.

Conclusion

Firms face different obstacles during the innovation process. We analyzed the obstacles to innovation faced by SMMEs by using the South African Business Innovation Survey data. The analysis was done at two levels: the decision to invest in innovation and the factors influencing the intensity of innovation among

SMMEs. The main results indicated that cost and institutional obstacles were significantly more important as disincentive factors for medium-sized enterprises while knowledge obstacles were significant as a disincentive factor for large enterprises. Interestingly, none of the factors was found to deter the decision to invest, nor the innovation intensity, among small and micro enterprises. The findings reveal that SMME's heterogeneity is crucial in explaining innovation and developing policy instruments to support innovation.

However, this study has not exhaustively identified all the obstacles to innovation faced by SMMEs in South Africa and more research is needed to identify the factors that constrain innovation, particularly in small and micro firms. This study paves the way for more research in sub-Saharan Africa that compares the obstacles as well as the capabilities for innovation by firm size class and categories.

Notes

1. Two of the authors were CeSTII employees and therefore had access to the data. As per the employee code of conduct at CeSTII and the HSRC, firm-level information was treated with strict confidence by all authors.
2. While employment numbers are recommended by the Oslo Manual to categorise firms into different sizes, this was not possible since the business register did not have sufficient information on employment (CeSTII 2020).

Disclosure statement

No potential conflict of interest was reported by the authors.

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