Essays on Innovation and Technological Change in South African Enterprises

PhD in Economics with a specialisation in Industrial Development

Dissertation

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The first essay is a case study focusing on the adoption and effect of 4IR technologies in the grain agricultural sector in South Africa. This is a qualitative study and will cover only formal agricultural enterprises. The second essay is on innovation factors in the agricultural sector and will use the data sourced from the HSRC Agri-BIS survey. The third essay is on the effects of cross-industry collaboration, and employee participation on firm innovation performance.

There are three essays:

1. Firm innovation and technological capabilities: A case study on 4IR adoption andeffect in the grain agricultural sector.
2. Determinants of Innovation Factors in Agriculture in South Africa.
3. The effects of cross-industry collaboration, and employee participation on innovation performance: Evidence from micro and small enterprises in Johannesburg, SouthAfrica.

Essay 3

The effects of cross-industry/external collaboration, and employee participation on innovation performance: Evidence from micro and small enterprises in Johannesburg, South Africa

1. Introduction

The primary focus of this study was on the analysis of the relationship between external collaboration, employee participation, and innovation performance. Advanced economies are continually focused on sustaining their competitive advantage bypositioning themselves ahead through technological innovations and advancements. A lot of innovation is built upon existing knowledge (Schumpeter, 1939). This paper examined the impact of demographic identity and multi-level factors that affect innovation in micro and small enterprises in Johannesburg, South Africa.

The processes of entrepreneurship and innovation occur in a variety of contexts involving multiple stakeholders and are both social and relational. Through the lens of gender identity, researchers have been exploring innovation processes and macro and micro factors of innovation. Studies show that gender dynamics have been rarely explored in innovation research. This study found that external collaboration and innovation performance follow an inverted U-shaped relationship. This is consistent with the findings by (Duysters & Lokshin, 2011; Oerlemans et al., 2013; Hottenrott & Lopes-Bento, 2016), indicating that the relationship between the breadth of collaboration and innovation performance follows an inverted U-shape. First, regarding innovation performance, this study followed the firm-level analyses that are in line with past studies (Laursen & Salter, 2006), concluding that innovation performance is positively curvilinearly with collaboration at the firm level.

The results indicate that there is a strong positive relationship between employee participation and innovation performance, characterised by a linear positive relationship. Similarly, innovation performance on the firm-level analyses indicates a positive, curvilinear relationship between external collaboration and innovation performance. Embracing complementary expertise and

adding additional value through external collaborations can be viewed as valuable innovation resources, contributing to firms' advancement of new technologies and new product innovation (Zhou, Yao, & Chen, 2018).

Even though past studies of the firm level indicate that such a relationship is present for the collaboration breadth and depth, (Kobarg, et al., 2019) replication analyses are in support of such a relationship for neither dimension. Collaboration breadth is defined as the number of different partner types that the firm has collaborated with for innovation, while collaboration depth refers to the intensity and closeness of collaborating partner types, which impact innovation (Laursen & Salter, 2014; Hagedoorn et al., 2018). This study did not directly investigate the reasons for the differences between the project-level and firm-level results, but the comparison between this study and previous studies provides valuable insights.

2. Overview

Innovation is driven by a few factors, such as technology fusion, shorter innovation cycles, the ability of the workforce to move across industries, and global access to knowledge, which then make the accumulation of external technologies in the value chain much easier (Enkel & Gassmann, 2010; Enkel, 2010). According to Love and Mansury (2007), external linkages with external parties enhance innovation performance through the introduction of new services by partnering with customers, suppliers, and strategic alliances. Firm-level core capabilities for production and innovation involving specialised suppliers are enhanced by inter-firm linkages (Roelandt & Den Hertog, 1999).

A study conducted by Bolívar-Ramos (2019) conceptually explained how geographic and institutional distances may affect the ability of a new venture to benefit from broad external linkages for innovation. According to it, knowledge transfer and business relations are affected by the interplay of these factors. Innovation is a driving force for technological progress and economic growth, as it meets the current market’s demands and the potential needs of future markets (Kassa & Mirete, 2022).

A firm's ability to innovate is largely determined by its ability to acquirenew knowledge (Cohen and Levinthal, 1990; Yli-Renko, Autio, and Sapienza, 2001; Lowik, van Rossum, Kraaijenbrink, and Groen, 2012).

The findings of McGrath et al. (2022) and Seigner et al. (2022) highlight the need to explore micro-level factors that contribute to innovation in businesses and individuals.

3. Research question

What are the effects of cross-industry/external collaboration, and employee participation on innovation performance in micro, small and medium-sized enterprises?

4. Original contributions to knowledge

This study will contribute to knowledge by examining the effects of cross-industry collaboration and employee participation on innovation performance in the micro and small enterprises in Johannesburg. Employee participation and firms' strategic alliances are some of the widely researched topics. Cross-industry collaboration is important for instance, in sharing risks and accessing new markets while employee participation adds value in organizations as a key originator of innovative ideas, amongst others.

5. Literature review

There is limited literature on the effects of industry collaboration on firm innovation performance. Much literature has focused mainly on university-industry collaboration and collaboration networks' effects on innovation in a specific industry or sector. Innovation performance through the introduction of new services is significantly enhanced by external links, such as those involving customers, suppliers, and strategic alliances (Love & Mansury, 2007). Using extra-cluster linkages, Chandrashekar & Subrahmanya (2019) in their study found that innovation performance in clusters depends on the firm's ability to integrate the global value chain both vertically and horizontally.

The firm's innovation increases when it has a highly qualified workforce, equally so, unqualified employees also contribute to the innovation of the firm (Love & Mansury, 2007). A study conducted by Cao, Derudder, Dai, & Peng (2022) indicated that in the context of urban innovation, (1) There is a positive relationship between intra-and interregional linkages; (2) when combined with triadic closure and structural gaps, these linkages facilitate cities' innovation capacity more effectively, and (3) intra and interregional linkages help facilitate cities' innovation capacity more effectively.

5.1. Cross-industry/External collaboration

The phenomenon of cross-industry innovation as it relates to the automotive industry is conceptualized by (Gassmann et al., 2004; Enkel & Heil, 2014). Small start-ups and established companies are specifically examined by these authors for cross-industry collaboration. Even though the notion of cross-industry innovation has only been described theoretically, the value of knowledge, technologies and partners at a high cognitive distance has only begun to become apparent (Enkel, 2010). External collaboration is an adequate process for small and medium-sized enterprises (SMEs) to enhance innovation performance and achieve sustainable competitiveness (Lu & Yu, 2020).

Prior research indicates that effective product innovation can result from collaboration with suppliers, customers, competitors, and research organizations (Tsai, 2009). In a survey of Spanish manufacturing companies, Nieto and Santamaría (2007) conducted a regression analysis and found

a positive correlation between product innovation and collaboration with suppliers. On the contrary, according to Sánchez and Pérez's (2003) analysis of Spanish manufacturing firms, collaboration with suppliers does not enhance new product performance.

To the very least, these studies indicate that even though there might be a positive relationship between product innovation and external collaboration, the relationship might not always result in significantly improved new product performance. Collaborating with suppliers can be highly beneficial for firms as it allows them to leverage the expertise and different perspectives of their suppliers to improve their solutions and develop new products (Bonaccorsi and Lipparine, 1994; Eisenhardt and Tabrizi, 1995).

Involving suppliers also helps firms identify potential technical issues, which can speed up new product development and enable more responsive market strategies (Kessler and Chakrabatri, 1996). Freel (2003) analysed small and medium-sized UK manufacturing firms and found that collaboration with suppliers has no significant impact on new product performance. The authors Ledwith and Coughlan (2005) investigated a sample of electronics companies in Ireland and the UK.

They found that there was no significant correlation between collaboration with suppliers and product innovation performance. Similarly, Belderbos et al. (2004a) conducted a study on Dutch manufacturing firms and discovered a negative, but not significant, relationship between collaboration with suppliers and product innovation performance. Collaborating with customers is a crucial factor that can help firms improve their product innovation performance.

Several studies have highlighted the importance of working with customers in identifying market opportunities for technology development (Gupta, et al., 2000; Fritsch and Lukas, 2001; Brockhoff, 2003). Additionally, engaging customers during the early stages of development can help reduce the likelihood of poor design (Tsai, 2009). Involving influential customers can also lead to gaining new ideas about solutions and identifying market trends early on, which increases the chances of new product development and success.

This, in turn, can provide firms with a competitive advantage in terms of product innovation (Souder et al., 1997; Li and Calantone, 1998). Hence, customer involvement is an effective approach that can help firms achieve product innovation advantages. Several studies have discovered that collaboration with customers has a positive impact on product innovation performance (Sachwald, 2003; Freel, 2003; Faems, et al., 2005). However, according to Heshmati's (2002) analysis of the performance of Swedish manufacturing firms, there was a negative correlation between customer collaboration and new product innovation.

Nieto and Santamaría (2007) discovered that customer collaboration positively impacts product innovation with marginal changes but does not affect significant innovation with new functions. Belderbos et al. (2004a) found no significant association between collaboration with customers and changes in new product sales. Meanwhile, Monjon and Waelbroeck's (2003) studyon French manufacturing firms revealed that customer collaboration has no significant impact onproduct innovation.

Collaborative networks are an important way for firms to achieve product innovation. However, collaborating with competitors is the least frequent type of collaboration adopted by firms. According to Bayona, et al. (2001) and Nieto and Santamaría (2007), even though this type of collaboration is not very common, it still provides some advantages. For instance, firms involved in a cooperative agreement can share technological knowledge and skills, producing a synergistic effect on solving common problems that are outside the competitor's area of influence (Tether, 2002).

The case study conducted by Inkpen and Pien (2006) suggests that firms collaborating with competitors may perform better in innovation than they would otherwise. Companies can enhance their capability development by collaborating on research and development, thereby decreasing the time and risk involved in technological innovation (Belderbos et al., 2004a). In addition, partnering with competitors allows firms to better understand their competitors' technological level, which can help them differentiate themselves (Linn, 1994).

5.2. Employee participation

According to Rao (2016), there is a relationship between employee engagement and organizational innovation. In addition to employee engagement, Langelaan, Bakker, Van Doornen, and Schaufeli (2006) identified employee engagement as a key antecedent of creativity and innovation. They found that heightened connections between employees and their work, which are fuelled by neuroticism and extraversion, stimulate creativity and innovation. Interestingly, Sundaray (2011) notes that engaged employees are more likely to be creative and innovative because they enjoy what they do. Employees are a very important strategic resource, and as noted, a key source of creativity and innovation.

Employee participation in the study entails employee involvement in the decision-making processes and activities related to innovation in a firm. As key inputs in the value creation process, employees' knowledge, expertise, and commitment are often necessary for innovative initiatives to succeed (Youndt, Snell, Dean, & Lepak, 1996). Janssen (2000) talks about innovative work behaviour (IWB) and argues that innovation is a result of employees developing, promoting, and implementing new ideas. Employees can openly expresstheir opinions, promote new ideas, and integrate them throughout the company (Dorenbosch, Engen & Verhagen, 2005). Therefore, employee participation influences innovation performance.

5.3. Innovation performance

Innovation is the application of a new idea or behaviour to improve the status quo (Jime´nez-Jime´nez & Sanz-Valle, 2011:409; Saunila, 2016:163). Catalyses the development of new products, processes, and ways of working. By exploring uncharted territory, it embraces change and the discovery of what works better. Furthermore, innovation is driven by the creative forces behind socioeconomic and scientific progress, with contributions from both the public and private sectors. By contrast, the literature on the direction of innovation in the industry has started with the organizational effect of such innovations on incumbents (Teece, Pisano, & Shuen, 1997).

Moreover, researchers can distinguish and group these types of innovations taking place within organizations in different industries. In this manner, established companies mimic the behaviour of emerging companies that are eager to ensure that innovation levels remain high and continue to increase their customer's expectations across product lines (Azoulay, Jones, Kim, & Miranda, 2020). Micro and small enterprises might not have similar resources, extant knowledge, and financial means to compete with the incumbents. This is because they perform poorly on dimensions that are currently valued by many consumers in the market (Azoulay, Jones, Kim, & Miranda, 2020), thus, the integration of these technologies into incumbent product lines would be costly.

For companies to remain innovative, unique products must meet the changing needs of their customers constantly (Kakati, 2003). Thus, a firm's innovation level can be determined by both the novelty of inventions and their commercialization (Birchall, Chanaron, and Soderquist, 1996).

5.4. Small, Micro and Medium-Sized Enterprises (SMEs)

There is considerable variation in the definitions of Small, Micro- and Medium-sized Enterprises (SME/SMMEs) in South Africa, making the task of precisely defining them difficult. Variations are influenced by capitalization, sales margins, and employee numbers (Asah et al., 2015:310; NCR, 2011). South Africa's economy relies heavily on SMEs. By 2030, South Africa will need to create an additional 11 million jobs and more than three million of them will be for young people, according to the National Development Plan. Most of these jobs will be created by expanding SMEs. SME sector estimates differ in South Africa despite this policy imperative. According to the Bureau for Economic Research, SME contribution to GDP (before taxes and subsidies) is slightly more than 20%.

5.5. Conceptual framework and hypotheses development

Innovation collaboration involves complementary innovation activities with shared objectives and active participation among partners, representing a particular type of open innovation (Enkel et al., 2009; Kobarg et al., 2019). Initially, open innovation focused on the positive potential of open innovation, however, recent research has delved into the negative aspects of it (Knudsen and Mortensen, 2011; Salge et al., 2013; Kobarg et al., 2019). This study considered both the detrimental and beneficial effects of open innovation at a firm level.

The beneficial aspects of open innovation are rooted in three primary conceptual channels (Kobarg et al., 2019). Initially, from the knowledge-based view (Nonaka, 1994; Grant, 1996, 1997), which provides that innovation collaboration is related to knowledge acquisition that is absent from the organisation (Chesbrough, 2003; Grant and Baden-Fuller, 1995). The primary example of knowledge acquisition that is not present in the firm can be information about customer needs, market demands or knowledge about a particular technology (Von Hippel, 1994; Belderbos et al., 2006; Tödtling et al., 2009).

Innovation collaboration extends the extant knowledge that is present at individual firms, which is a primary driver of innovation (Conner and Prahalad, 1996; Sood and Tellis, 2005). The second aspect is the organisational learning view (Fiol and Lyles, 1985; Argote and Miron-Spektor, 2011; Argote, 2013), which provides that learning of new skills and specialised knowledge associated with a particular technology and market is enabled by the innovation collaboration aspect of open innovation (Kogut and Zander, 1992; van Beers and Zand, 2014).

Lastly, in the resource-based perspective (Barney, 1991; Wernerfelt, 1984), innovation collaboration is viewed as a way of accessing external resources by collaborating firms (Mowery et al., 1998; Ahuja, 2000; Wassmer and Dussauge, 2012), including financial resources risks related to the uncertainty of innovation (e.g., specialised technology) (Das and Teng, 2000; Belderbos et al., 2004a). The detrimental effects of innovation collaboration that have been observed include diminishing marginal returns (Kobarg et al., 2019), transaction and opportunity costs (Laursen and Salter, 2006; Salge et al. (2013) that might result in detrimental effects on innovation performance (Keijl et al., 2016). The process of idea generation involving the

application of innovations in society is often limited to groupthink (Fox, 2019). Several factors determine innovation in small, micro and medium-sized businesses is determined by several factors.

Enterprise innovation ability is determined by size and age, R&D efforts, the quality of managers and staff, employee participation and motivation, management practices, cross-departmental collaboration, knowledge exchange, the firm's network, and factors specific to the industry (Egbetokun et al., 2016; Kassa & Mirete, 2022). Another factor that motivates enterprises to innovate is the competition among them. A competitive enterprise can adopt innovations when there is intense competition (Chesbrough & Crowther, 2006; Frishammar & Ake Horte, 2005; Nguyen, 2007; Nicita et al., 2005; Santamaría et al., 2010; Kassa & Mirete, 2022).

Additionally, competition helps enterprises thrive, achieve growth, continually improve their environments and significant aspects of their outer condition, and improve their operational effectiveness (Soini & Veseli, 2011; Ngibe & Lekhanya, 2020; Beach, 2017; Pickard-Whitehead, 2018; Zelga, 2017). Entrepreneurship training cascaded to owners of micro and small businesses is the first factor determining the level of innovation in those companies. By coordinating the available resources, training assists owners in gaining a competitive advantage (Barney & Wright, 1998).

Investing in manpower development, acquiring knowledge, and skills, and acquiring competence is essential to achieve enterprise transformation (Becker, 1964; Kassa & Mirete, 2022). Human resource training has been shown to positively impact enterprise performance and innovation in several studies (Zheng et al., 2006; Kassa & Mirete, 2022). For an organisation to become innovative, empowerment, promotion from within, training, and skill development are primary practices (Rosli, & Mahmood, 2013; Kassa & Mirete, 2022). There is a growing trendin SME sectors across the globe, but in South Africa, this important economic sector seems to be contracting (SME Growth Index, 2015).

In South Africa, more than half of SMEs fail before they can become established businesses (Mbonyane & Ladzani, 2011:552). Razak and Othman (2012:165) provide that innovating continuously is mandatory for organisations to succeed in achieving meaningful growth, without

continuous innovation, failure is inevitable. Organisations with a competitive advantage and innovative capability are successful (Furawo & Scheepers, 2018). Thus, in South Africa, SMEs that wish to survive must devise a winning strategy that upholds a deep understanding of factors affecting their innovative capacity (Furawo & Scheepers, 2018). In addition to understanding innovative capacity as the key to a firm's competitive advantage, innovation can result in sustainable advantages for a firm.

In summary, the firms can increase their innovation performance in the form of product innovation through external collaboration (e.g., suppliers, research centres, etc.) and firm innovation performance is influenced by employees' involvement/participation in the product innovation. This study further argues that once the knowledge and learning between firms is saturated in the market of certain products or services, the innovation performance ceases to increase even though the firms continue to collaborate.

Numerous studies found that distance and frequent interaction between firms counter the low ease of learning (Lane et al., 2006; Luca and Atuahene-Gima, 2007; Kobarg et al., 2019), thus, that then leads to "high complexity and cognitive distance" (Enkel and Gassmann, 2010; Nooteboom et al., 2007; Kobarg et al., 2019) of knowledge needed for innovation performance; ideally argued to be far from the firm's extant supply of knowledge (McGrath, 2001; Nooteboom et al., 2007; Rosenkopf and Almeida, 2003).

Close and frequent interactions are crucial to building trust and reciprocity in business relationships (Dyer and Singh, 1998; Gulati, 1995; Schilling and Phelps, 2007). When partners trust each other, they are more willing to share information and knowledge (Ahuja, 2000; Schilling and Phelps, 2007), which in turn facilitates the exchange of tacit and complex knowledge (Hansen, 1999). This type of knowledge exchange is essential for innovation performance. Trust also helps to establish long-term relationships between partners, which is beneficial for product innovation.

In this study, firstly, (H_1) I argue that firm innovation performance will benefit from external collaboration and employee participation. Secondly, (H_2) since innovation collaboration leads to both beneficial and detrimental effects of open innovation, the relationship between external collaboration and innovation performance will follow an inverted U-shape (for example, due to

diminishing marginal returns). Lastly, (H_3) I argue that there is a positive relationship between employee participation and innovation performance at a firm level.

Thus, I hypothesize that:

Hypothesis 1 (H_1) There is a positive relationship between external collaboration, employee performance, and innovation performance.
Hypothesis 2 (H_2) The relationship between external collaboration and innovation performance will follow an inverted U-shape.
Hypothesis 3 (H_3) There is a strong positive relationship between employee participation and innovation performance.

Table 1: Research *hypotheses*

6. Methodology (including data)

This study used the data collected by SARChI-ID from micro and small enterprises in Johannesburg through semi-structured questionnaires. SARChI-ID data used for this study is from the second wave (survey) that had just been completed. SARChI-ID data will be used for this study, the second wave (survey) is on the field. The survey covers firms' demographic and business profiles, innovation processes, training and skills development, linkages, and financial dimensions.

The data was collected by SARChI-ID frommicro and small enterprises in Johannesburg through semi-structured questionnaires. The data will be collected by SARChI-ID from micro and small enterprises in Johannesburg through semi-structured questionnaires. The survey covers firms' demographic and business profiles, innovation processes, training and skills development, linkages, and financial dimensions. Innovation performance will be estimated using econometric methods based on a single factor, dependent variable.

Firms will be asked about their demographic and business profiles, innovation processes, training and skills development, linkages, and financial dimensions. The survey questions on innovation follow the Oslo Manual (OECD/Eurostat, 2018). The data is representative of micro and small firms in Johannesburg. The survey covered all enumerator areas (EAs) in the City of Johannesburg that are classified as commercial or industrial in the urban development zone (UDZ),as well as any adjacent residential EAs that also have manufacturing activities. The final sample consisted of N = 1021 manufacturing SMEs in the City of Johannesburg, Gauteng, South Africa.

The determinants of the measure of innovation performance (Tobit analysis), such as the novelty of innovation will be explored. The survey focuses on innovation while covering several aspects such as firm characteristics and behaviour (There is a table for the questions utilized in this study). Firms were asked about their demographic and business profiles, innovation processes, training and skills development, linkages, and financial dimensions.

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development zone (UDZ),as well as any adjacent residential EAs that also have manufacturing activities.

7. Model

The dependent variable is characterised by two anomalous dimensions. The first is the number of products innovated from new or significantly improved innovative products and/or services, which ranges between 1 and 4. Secondly, since many SMEs indicated none/not at all in terms of new or significantly improved innovative products, a number of the observations have a value equal to five (5) for the dependent variable. Based on the above points, and of course, the fact that the Tobit regression model is a widely used technique for modelling censored variables in econometrics research (Gujarati, 1995; Austin, Escobar, Kopec, 2000).

Furthermore, the fact that the dependent variables are censored, the Tobit model is used *(Amemiya, 1985; Wooldridge, 2010).* Moreover, as the hypotheses indicated the inverted U-shaped relationships between the independent and dependent variables, the proposed Tobit model as an instrument is effective enough to identify the presence of such a relationship (Kobarg et al., 2019). The literature proposes that meeting three criteria is necessary to establish confidence in the existence of such a relationship *(Haans et al., 2016; Lind and Mehlum, 2010):* (1) The linear and squared terms of the independent variable have inverted significant coefficients.

In summary, to have an inverted U-shape, the linear term should have positive significant coefficients, while the squared term has a negative, significant coefficient. (2) The estimated turning point of the curve falls well within the range of the data. This study uses a test to detect curvilinear relationships in all of our analytical steps. For a relationship to be classified as curvilinear, all conditions are required to be met. The test is applied at both ends of the data range, where the curves are steep enough.

For empirical purposes, the following Tobit estimation model is considered to test the proposed model:

$$\text{Product Innovation}_{t} = \beta_0 + \beta_1 \ln(\text{Size}_t) + \beta_2 \ln(\text{Age}_t) + \beta_3 EP + \beta_4 R\&D + \beta_5 EC + e_t$$

EP = Employee participation

R&D = Research & Development

EC = External collaboration

ln = Control variables vector

e_t = *error term*

8. Measures and variables

8.1 The dependent variable

Innovation performance will be measured by whether the SMEs have introduced new or significantly improved products or services to the market. Thus, product innovation is used as a dependent variable, which measures the products innovated in the last year of the Innovation in Micro and Small Enterprises in Johannesburg survey as a result of new or significantly improved products introduced over the last three (3) years. The variable has a scale ranging between 1 = entirely new) and 5 = None/not at all. This type of operationalising innovation performance variable is consistently used in innovation studies in similar contexts (Miller and Friesen, 1982; OECD, 1997; Frishammar and Hörte, 2005; Tsai, 2009; Berchicci, 2013; Kobarg et al., 2019).

8.2 Independent variables

Every study of innovation, regardless of its focus on manufacturing or service, includes a question regarding size (Shan, Walker, & Kogut, 1994; Tether, 1998; Grupp & Maital, 2000; Meeus and Oerlemans, 2000; Galende & de la Fuente, 2003; Hagedoorn & Cloodt, 2003; Swamidass, 2003; Tether, 2005; Love & Mansury, 2007; Antonelli & Scellato, 2015). Numerous studies have demonstrated a positive correlation between firm size and innovation activities *(Ettlie and Rubenstein, 1987; Acs and Audretsch, 1988; Santarelli and Sterlacchini, 1990*; Love & Mansury, 2007).

A qualified workforce will aid an organization's innovation efforts (Love & Mansury, 2007). According to the research of Freel (1999) on small and medium-sized companies, innovative firms are significantly more likely to hire graduates than their less innovative competitors. To achieve innovation, research and development are among the most important factors. Several studies have been conducted on the role of R&D in innovation (Love & Roper, 1999, 2002; Veugelers & Cassiman, 1999; Antonelli, 2000; Hipp, 2000; Preissl, 2000; Bougrain & Haudeville, 2002; Furman, et al., 2002; Silverberg, 2002; Hagedoorn & Cloodt, 2003; Leiponen, 2005).

According to Scherer (1965,1991), differences in the technological opportunity environment are important in determining the relationship between R&D and innovation activity. Companies can

increase their innovation capacity by collaborating with external firms (Hagedoorn 1993; 2002; Faems et al., 2005).

8.3 Control variables

I controlled for two variables in this study in the explanations of effects on innovation performance. I will control for both the firm size and age, as they can affect innovation performance (Chaganti & Parasuraman, 1996; Dai et al., 2019; Tang, 2015). In this study, I have factored in the age and size of the firms. The age of the firm will be measured as the natural log of the firm's age at the time of data collection. This is because older firms tend to be more conservative and may be less willing to take risks in innovation due to resource constraints (Dai et al., 2019; Madison, Moore, Daspit & Nabisaalu, 2022). By controlling for these factors, I can better understand the impact of other variables on innovation performance.

Previous research has identified specific factors that impact a firm's innovation performance and need to be taken into account (Berchicci, 2019) as controlled variables. The size and age of a firm are recognised factors that affect its innovation output. To control them, size is expressed in the logarithmic form of the total number of employees, and age is calculated as the logarithmic form of the number of years since the firm's establishment (Berchicci, 2019).

9. Analysis

9.1 Results

Table 2 presents the descriptive statistics of the variables, which includes the mean and standard deviation of all variables. Table 3 shows the correlation between variables. The table shows a negative and weak correlation between firm Age (-0.02), firm Size (-0.19) and innovation performance. It suggests that micro and small manufacturing enterprises' size and age have a small effect on the overall firm innovation performance (i.e., product innovation). Meanwhile, the micro and small manufacturing enterprises' R&D (0.57), Employee participation (0.3) and External collaboration (0.10) have a positive and strong correlation with innovation performance. Cohen (2013) concluded that a correlation of 0.10 is considered a small effect size, 0.30 is considered a medium effect size, and 0.50 explains a large effect size.

Table 4 presents three Tobit models with robust estimations. Model 1 shows the relationship between the control variables and innovative performance. A firm's Size, R&D, Employee participation and External collaboration positively affect innovative performance, while the contribution of a firm's Age is not significant. The firm's Age has a negative coefficient and is not significant. This finding suggests that having an effective innovation collaboration and continuously increasing specialised knowledge derives high gains and strongly influences a firm's innovation performance.

The AGE variable shows a positive yet not significant effect on innovative performance. Model 1 examines whether employee participation has a linear effect and includes its squared term. Furthermore, Model 1 indicates the inverted U-shaped line of the relationship between external collaboration and innovation performance. Model 1 presents a chi-square with a value of *LR Chi-Square* 656.*94.* The curvilinear effect on innovative performance is shown graphically in Figure 2, illustrating an inverted U-shaped, indicating the presence of the relationship between External Collaboration and the firm's innovation performance. Figure 2 indicates such a relationship between external collaboration and innovation performance, thus, confirming H2.

It implies that firms that engage in external collaboration activities have enormous benefits in

terms of innovative performance. The results indicate that both external collaboration and its

squared terms are significant. The direction of the signs of the two coefficients indicates that the positive relationship decreases or becomes negative with increasing values of external collaboration, thus indicating an inverted U-shaped relationship.

Further evidence confirms a U-shaped relationship between external collaboration and innovation performance based on the location of the turning point and steepness of the slopes. H1 is confirmed by Table 4, which shows the positive relationship between the values of external collaboration, employee participation and the predicted values of innovation performance (i.e., product innovation). This study finds the linear relationship between employee participation and innovation performance to be significant.

Hence, that means that it is in support of H3. Employee participation, thus, does appear to influence the innovation performance of micro and small manufacturing enterprises in the City of Johannesburg. Considering the effects of employee participation on innovation performance, shown in Figure 1 (Graph 1) confirms the positive linear relationship. Figure 2 indicates the turning points and slopes, which confirm the existence of an inverted U-shaped relationship. Therefore, that further confirms the hypothesis H2, which anticipates the presence of a positive, curvilinear relationship between external collaboration and innovation performance.

Explaining these results is difficult since external collaboration for this study includes different types of contributors, including users of individual employees, individuals external to the business, groups of employees in your business unit, communities of people external to the business, and other enterprises or institutions. In summary, these results confirm that collaboration with other micro and small manufacturing enterprises affects innovation performance.

Table 2:

Descriptive statistics

Variables	Mean	Standard deviation	Min.	Max.
1. Product Innovation	**2.987267**	**1.823279**	**1**	**5**
2. AGE	**2.259199**	**.7892884**	**0**	**4.510859**
3. SIZE	**1.135491**	**.8431108**	**0**	**3.912023**
4. R&D	**.5710088**	**.4971506**	**0**	**2**
5. Employee participation	**.8932419**	**.3089568**	**0**	**1**
6. External collaboration	**1.332027**	**.4834949**	**1**	**3**

Note: N = 1021

Table 2 describes the variables and descriptive statistics of interest. The correlations between variables are shown in Table 3. This study introduces several control variables to account for unobserved heterogeneity in line with the literature. By using the Tobit regression method exclusively, this study considers unobserved heterogeneity not to be a significant concern. As per the methodological literature, unobserved heterogeneity is considered, at most, a small problem in Tobit regression and its estimation of marginal effects (Greene, 2005; Wooldridge, 2005, 2010). Therefore, it is "surprisingly benign" (Greene, 2005, p. 707).

Table 3

Correlations between variables

Variables	1	2	3	4	5	6
1. Product Innovation	**1.0000**					
p-value						
2. AGE		**1.0000**				
p-value	**-0.0165 (**)**					
3. SIZE			**1.0000**			
p-value	**-0.1896 (**)**	**0.0893 (*)**				
4. R&D				**1.0000**		
p-value	**0.5867**	**-0.0236 (**)**	**-0.0789 (*)**			
5. Employee participation					**1.0000**	
p-value	**0.2604**	**-0.0155(**)**	**0.0115 (**)**	**0.1994**		
6. External collaboration						**1.0000**
p-value	**0.0893 (*)**	**-0.0239 (**)**	**-0.0611(*)**	**0.0221 (**)**	**0.0406 (**)**	

(N = 1021)

**** p<0.01 ** p < 0.05 * p<0.1.*

To study the impact of collaboration on innovation performance, previous studies at the company level, sometimes have presented a time lag between measuring collaboration and measuring innovation performance (Kobarg et al., 2019). This provides for the anticipated effects of collaboration activity on innovation performance to become more apparent.

Table 4

Results of Tobit regression for innovation performance

	Innovation performance		
	(Model I)		
	Coef.		*S.E.*
AGE	***.031***	***0.590***	***.0566415***
SIZE	***-.315***	***0.000(**)***	***.053278***
R&D	***1.995***	***0.000(**)***	***.0916939***
Employee participation	***.897***	***0.000(**)***	***.1472001***
External collaboration	***.236***	***0.011 (**)***	***.0923303***
Constant	***1.026***	***0.000(**)***	***.2318862***
Significance of u-test		*	
(external collaboration and Innovation Performance) [a]			
Log-likelihood	***-1807.8764***		
Pseudo R2	***0.3915***		
LR Chi-Square	*656.94*		
Prob > Chi-Square	*0.0000* ***(**)***		

*Note: N = 1021, *** p<0.01 ** p < 0.05 * p<0.1.*

[a] *t-test statistic for the formalised test of a U-shaped relationship based on OLS regression (cf. Lind and Mehlum, 2010; Kobarg et al., 2019).*

Graph 1

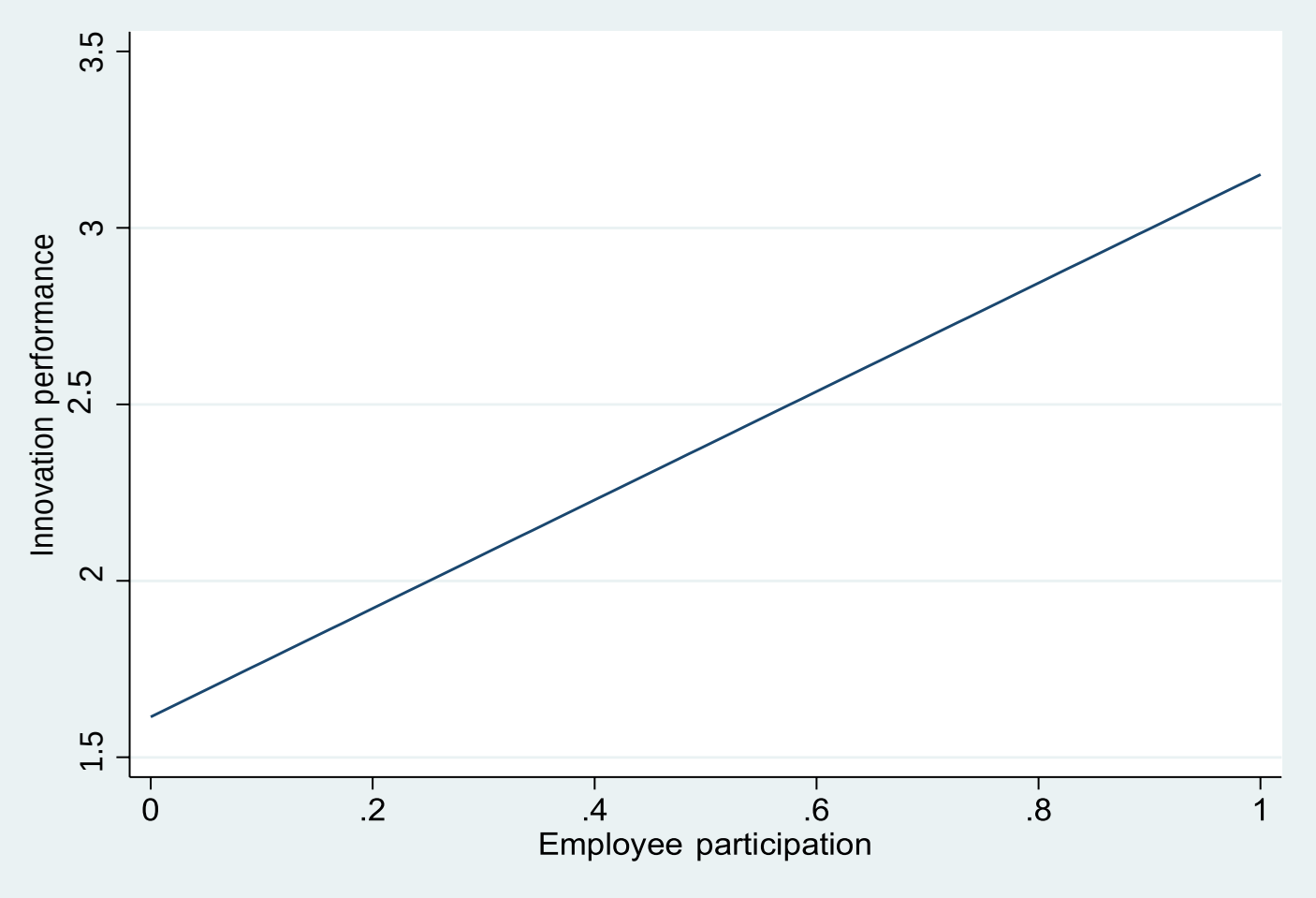

Fig. 1. The relationship between employee participation and innovation performance

Graph 2

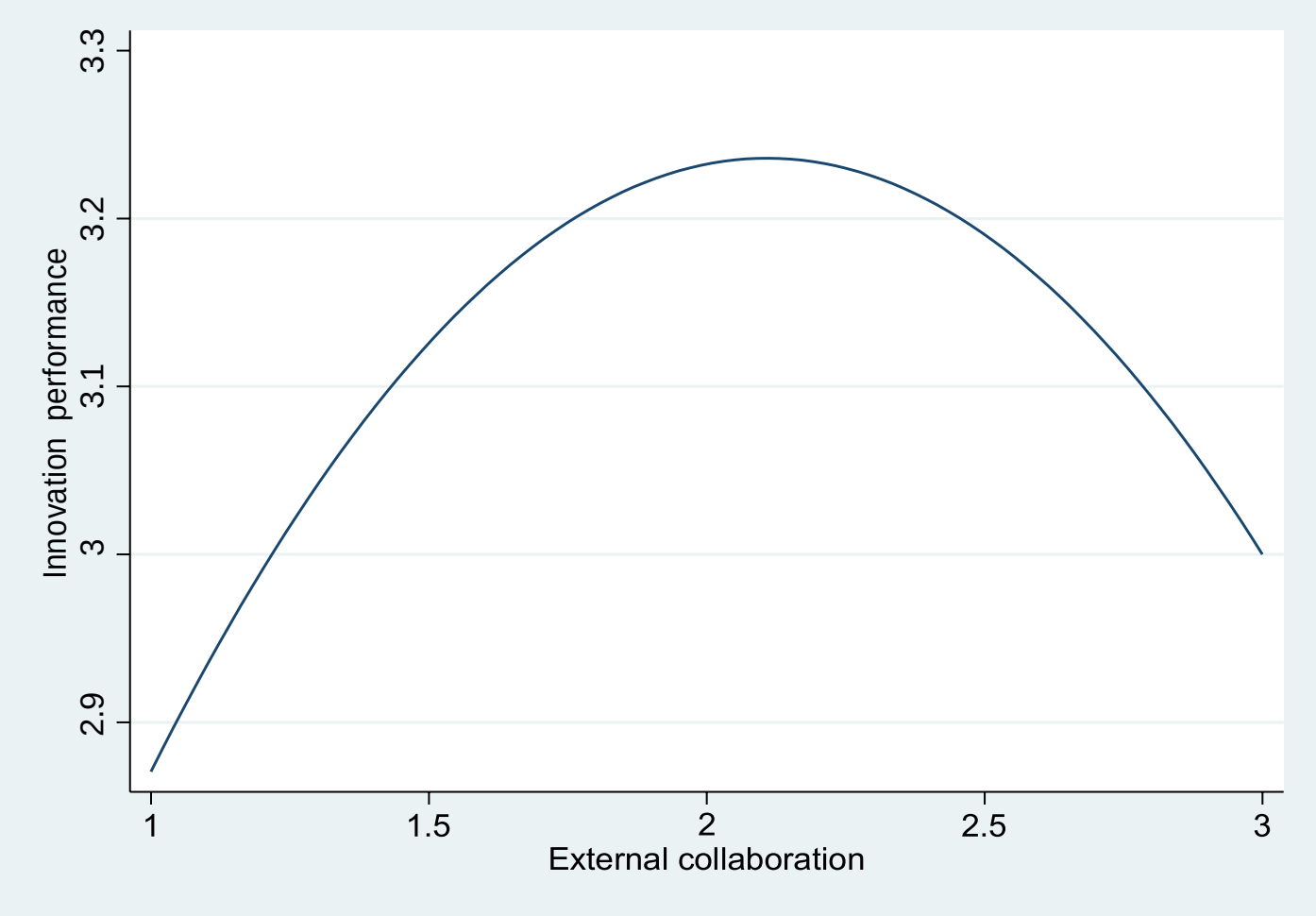

Fig. 2. The relationship between external collaboration and innovation performance

10. Discussions

This study aimed to investigate the effects of external collaboration (linkages) and employee participation on innovation performance at the firm level. This study found that external collaboration and innovation performance follow an inverted U-shaped relationship. First, regarding innovation performance, this study followed the project-level analyses that are in line with past studies (Laursen & Salter, 2006), concluding that innovation performance is positively curvilinearly with collaboration at the project level.

The results indicate that there is a strong positive relationship between employee participation and innovation performance, characterised by a linear positive relationship. Similarly, innovation performance on the firm-level analyses indicates a positive, curvilinear relationship between external collaboration and innovation performance. Embracing complementary expertise and adding additional value through external collaborations can be viewed as valuable innovation resources, contributing to firms' advancement of new technologies and new product innovation (Zhou, Yao, & Chen, 2018).

Even though past studies of the firm level indicate that such a relationship is present for the collaboration breadth and depth, (Kobarg, et al., 2019) replication analyses are in support of such a relationship for neither dimension. This study did not directly investigate the reasons for the differences between the project-level and firm-level results, the comparison between this study and previous studies provides valuable insights. From the methodological point of view, Kobarg, et al., (2019) suggest that one could argue that the findings differ both at the firm level and at the project level, the reason being the aggregation of the measures of the relationships from the project level and ended up ‘masking or levelling of variance’ (cf. Vanhaverbeke et al., 2014a).

11. Implications for theory and practice

This study significantly contributes to the understanding of external collaboration (linkages) and employee participation's impact on innovation performance. In analysing these relationships, this study contributes to the understanding of innovation performance and collaboration including past studies' results on the relationship between collaboration and innovation outcomes at the firm level (Shi, Zhang, & Zheng, 2019; Lu & Yu, 2020).

The effects of collaboration breadth and depth on radical and incremental innovation performance at the project level (Kobarg, et al., 2019), the effects of inter-firm linkages on SMEs open innovation in Chinese manufacturing SMEs (Mei, Zhang, & Chen, 2019), and the role of collaborative intensity and regional innovation efficiency (Broekel, 2012). This study contributes to a more comprehensive understanding of the collaboration, employee participation and innovation performance effects of innovation.

Moreover, this study contributes to the ongoing general open innovation discourse and debate on the innovation performance implications. Several studies argue that external collaboration is a positive action for small and medium-sized enterprises (SMEs) to increase innovation performance and achieve sustainable competitiveness (Lu, & Yu, 2020). Moreover, some indicate that the aggregation of project-level practices at the firm level is a potential explanation for differences in findings concerning the performance effect of innovation collaboration (Vanhaverbeke et al., 2014a; Vanhaverbeke et al., 2014b).

The results of this study contribute to the ongoing discussion regarding the influence of the unit of analysis on the results of investigations of open innovation and innovation performance, and they support the increasing "recognition that other units of analysis need to be considered as well to get a more detailed understanding of the antecedents, processes and outcomes of open innovation" (Bogers et al., 2017, p. 4; West et al., 2014).

Practitioners can benefit from the findings of this study. In addition, practitioners should consider the importance of external collaboration at the firm level to the performance of a project in terms

of innovation, which may be attributed to resource restrictions and the narrow focus characteristic of innovation projects (Kobarg, et al., 2019). In addition to guiding policymakers and venture capital firms, among others, in the creation of innovation incentives, the results of this study may be useful in guiding their decisions, as they provide guidance on the appropriate degree of collaboration within micro and small manufacturing companies and employee participation to maximise innovative outcomes.

12. Limitations and future research

First, the analysis is based on the firm-level data in micro and small enterprises in the City of Johannesburg during the survey time frame. The purpose of the survey was to allow DSI/NRF SARChI- Industrial Development at the University of Johannesburg to collect data at the firm level in order to gain a comprehensive understanding of the factors that drive or hinder innovation, including the continuity of innovation behaviour among micro and small manufacturing businesses operating within the City of Johannesburg, South Africa.

Therefore, the researcher is confident that the research questions of this study can be answered by the survey data. This study's analysis pertains to the micro and small manufacturing enterprises operating in the City of Johannesburg, to reduce the presence of overwhelming geographic and regional variations. Hence, the limitation of this study is that the results are only applicable to the City of Johannesburg's micro and small manufacturing enterprises and cannot apply to other sectors and locations. That being said, future research studies should focus on conducting comparative analysis on the subject across different sectors and geographic locations.

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